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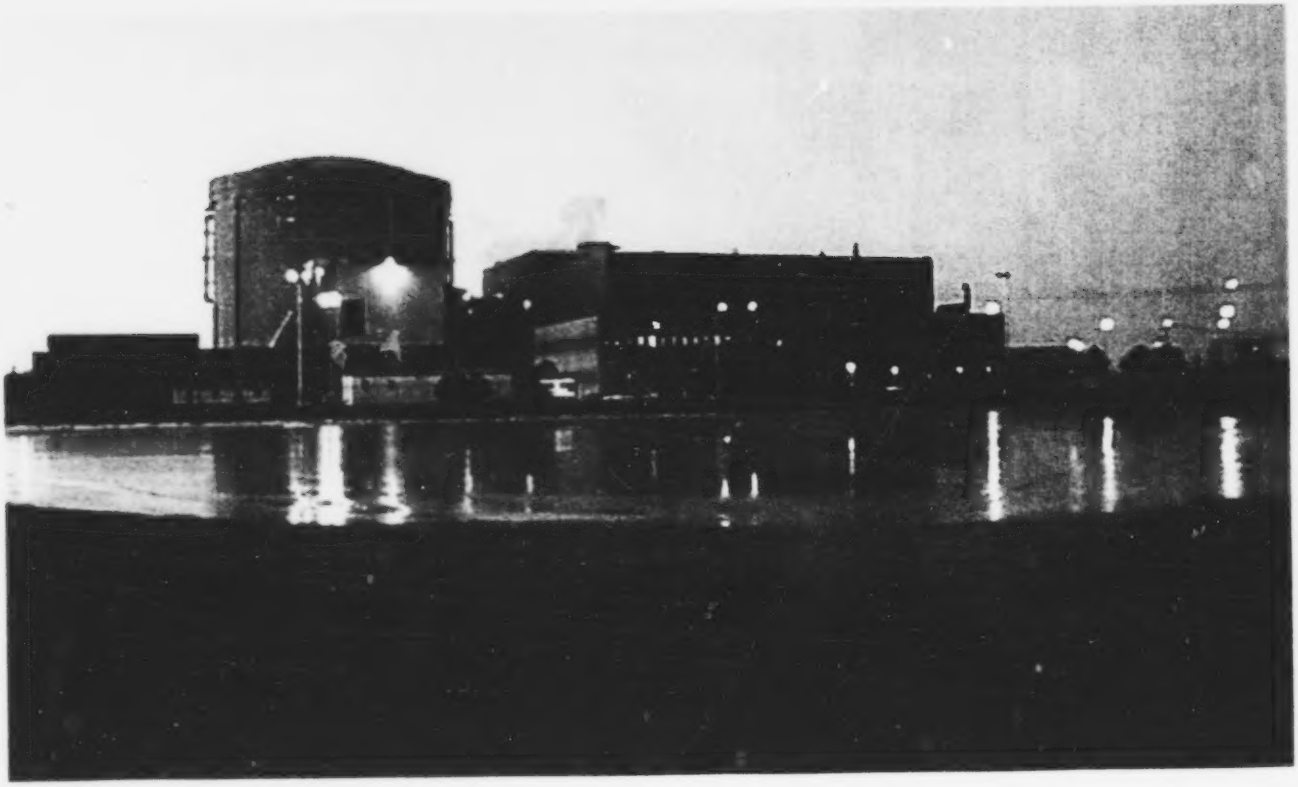
Point Lepreau Generating Station

Environmental Radiation Monitoring Data

January 1, 2005 to December 31, 2005



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POINT LEPREAU GENERATING STATION

Environmental Radiation Monitoring Data

January 1, 2005 to December 31, 2005

PREPARED BY: J.C. McCulley Joe M'Culley DATE: 2006-04-20

REVIEWED BY: R.P. Mapplebeck Ralph Mapplebeck DATE: 2006-04-20

APPROVED BY: J.C. Nason JCNason DATE: 2006-04-24

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Executive Summary

This annual report is a compilation of the 2005 results from the Environmental Radiation Monitoring Program for the Point Lepreau Generating Station (PLGS).

Since 1976, the monitoring program has analysed more than 32 000 samples to define background radiation from natural and human sources. The contribution from human sources has declined significantly since atmospheric bomb tests have ceased. The program detected radionuclide fallout in New Brunswick after a Chinese atmospheric bomb test in 1980, and fallout from the accident at Chernobyl in 1986. There have been no regionally detectable releases of radiation from any human activity since these two events.

In 2005, there were 1833 analyses performed on 1292 samples to monitor environmental radiation around Point Lepreau and across the province in general. There were 538 analyses performed on 322 other samples, including 358 analyses on 230 Quality Assurance (QA) samples.

The analyses indicate that radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the design and operating target for PLGS (50 microsieverts per annum).

Source of Dose to Critical Group	*Individual Dose ($\mu Sv \cdot a^{-1}$)*
PLGS airborne emissions	0.48
PLGS liquid emissions	0.06
natural background (estimate)	2000

The following trends were observed in the historical data:

- increasing concentration of tritium in Parshall Flume water from the Solid Radioactive Waste Management Facility (SRWMF) Phase 1. It is still below the peak concentration observed in 2000.
- continued low dose to members of the Critical Groups due to continued low emissions since 1995.
- continued low concentration of tritium in water vapour (onsite locations) since 1994.
- decreasing concentration of tritium in monitoring wells (near plant) since 2001.
- continuing detection of tritium in air and water samples (higher onsite than offsite).
- continuing difference between onsite and offsite thermoluminescent dosimeter (TLD) measurements.
- decreasing TLD measurements with distance from the SRWMF Phase 2 fence.

The stated objectives of the program were met in 2005.

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1 Introduction

The licence to operate PLGS, issued by the Canadian Nuclear Safety Commission (CNSC), requires that NB Power Nuclear maintain an Operational Environmental Radiation Monitoring Program (OERMP) during normal plant operations. This document describes the results of the program for the year 2005.

The requirement for this program is stated in *Radiation Protection Directives*(1) and *Solid Radioactive Waste Management Facility 2002 Safety Report*(2). The underlying reason for this is the large inventory of radionuclides that exist on site. The program operates in conjunction with *Online Monitoring and Control of Liquid and Airborne Effluents*(3), which monitors and controls effluents at their source. The Derived Emission Limits (DELs) are calculated in *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*(4).

As part of its overall Management System, Point Lepreau has an Environmental Management System (EMS) (5) in place that is registered to International Organization for Standardization (ISO) 14001(6). All activities and products that could impact the environment have been identified and logged in a database. From this, a list of significant environmental aspects (SEAs) was developed and it forms the foundation for the EMS. Management programs are in place for each of the SEAs to ensure compliance with the standards. The SEAs include radiological and non-radiological releases to water and air, waste management and accident management. Environmental assessment and improvement programs have been developed for the SEAs to ensure continual improvement.

All activities that support PLGS are controlled by the PLGS Management System. The environmental radiation monitoring program falls under the primary process *SU-02 Provide Environmental Services*(7). This process was mapped in 2002, and all sub-processes related to routine environmental radiation monitoring now come under it.

Monitoring of the site began in 1976 with the Pre-operational Program(8), which became the OERMP in 1982(9). PLGS was declared "in-service" in February 1983. All radionuclide analyses in 2005 were performed in the Fredericton Health Physics Laboratory at 420 York Street, Fredericton, NB by the three full-time staff members (Health Physicist, Senior Technical Specialist and Engineer/Scientist I-IV).

The radiation monitoring program for PLGS is reviewed annually. This ensures that the samples collected, their frequency of collection, and the analytical techniques used are appropriate to achieve the objectives of the program. Late in 1999, the basis of the OERMP was extensively revised to comply with *Guidelines for Radiological Monitoring of the Environment*(10), which did not exist when this program was first implemented.

The Environmental Radiation Monitoring Program for PLGS fulfils several objectives. These are to:

1) permit the estimation of dose to critical groups and populations from the radioactive emissions from PLGS and its Solid Radioactive Waste Management

Facility (SRWMF). This is achieved through the analyses of environmental and effluent samples.

2) provide data to confirm compliance of PLGS and the SRWMF with release guidelines and regulations and to provide public assurance of compliance. This is achieved through the issuance of the annual report to all interested parties.

3) establish and maintain the capability for environmental monitoring so that an effective response can be made to emergency conditions. This is achieved by maintaining the resources to step up the monitoring program during increased emissions that are only likely during an accident. The ability to interpret the data and make recommendations is also maintained.

4) maintain a database to facilitate the detection of trends. This is achieved by storing all results on a computer system that has the capability of reporting and graphing any desired subsets of the data.

5) verify or refine environmental models used in the calculation of Derived Emission Limits (DELs). This is achieved by comparing the theoretical dispersion factor with one calculated empirically. As well, other exposure routes to the public are continually evaluated.

6) determine the fate of released radioactive materials to show whether any significant pathway to humans has been overlooked. This is achieved through the collection and analysis of sample media outside of the established program. As well, any results that are not consistent with effluent results are investigated.

The capability of the radiation monitoring laboratory is assessed through the QA program and through the daily analytical checks. This demonstrates the accuracy and consistency of analyses.

The following sections will briefly describe the program. Details are provided on PLGS emissions, analyses results, trends, dose estimates, and the quality assurance program.

2 Point Lepreau Emission Data

Table 2.01 lists the production performance for PLGS since its beginning. Experience has shown that the years of lower capacity factors are usually the years with the lowest airborne emissions of most radionuclides, especially noble gases. The opposite is true for liquid emissions.

Table 2.01: PLGS Production Performance

Year	*Annual Gross Capacity Factor (%)*
1983	86
1984	90
1985	97
1986	94
1987	92
1988	96
1989	95
1990	96
1991	98
1992	87
1993	95
1994	94
1995	29
1996	83
1997	62
1998	68
1999	74
2000	71
2001	80
2002	68
2003	85
2004	78
2005	79
Lifetime (Since In-service)	82

Emissions from PLGS continue to be at low levels as indicated in Table 2.02. By the time these emissions reach the edge of the exclusion zone, they are diluted below the detection limits of most analytical procedures. Laboratory staff monitor the results of the emissions programs so that adjustments can be made to sampling and analysis protocols. There were no unusual emissions during the year 2005.

Table 2.02: Radionuclides Detected in Effluents

Nuclide	*Gaseous Effluent DEL $(Bq \cdot a^{-1})$*	*Emission (Bq)*	*Liquid Effluent DEL $(Bq \cdot a^{-1})$*	*Emission (Bq)*
H-3	4.3E+17	1.7E+14	1.6E+19	2.1E+14
C-14	3.3E+15	2.8E+11	3.0E+14	1.7E+09
Na-24	5.6E+15		-----------	
Ar-41	6.4E+16	3.9E+12	-----------	
Sc-46	1.7E+14		-----------	
Cr-51	2.4E+16		2.2E+15	1.0E+08
Mn-54	1.1E+14		6.4E+13	1.5E+06
Fe-55	-----------		5.1E+14	
Fe-59	4.0E+14		3.1E+13	1.9E+07
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12		1.8E+13	3.5E+08
Zn-65	7.1E+13		1.5E+13	
As-76	-----------		3.2E+14	
Kr-85	1.9E+19	4.9E+12	-----------	
Kr-85m	5.2E+17	2.2E+10	-----------	
Kr-87	9.4E+16	2.6E+09	-----------	
Kr-88	2.8E+16	5.0E+09	-----------	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13	2.2E+03	2.2E+15	1.0E+06
Y-90	8.2E+15		4.0E+15	
Y-91	-----------		3.1E+15	
Zr-95	1.7E+14		3.7E+13	1.1E+08
Nb-95	1.3E+14		1.1E+14	2.6E+08
Mo-99	5.4E+15		1.3E+16	9.1E+05
Ru-103	1.2E+15		1.8E+14	3.7E+05
Ru-106	7.7E+13		2.7E+14	
Ag-110m	3.8E+13		1.8E+13	5.0E+06
Sb-122	-----------		1.8E+14	1.6E+07
Sb-124	2.5E+14		4.8E+13	4.0E+07
Sb-125	-----------		1.9E+14	2.1E+06
Te-132	1.4E+15		2.9E+13	4.8E+05
I-123	-----------		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	***Gaseous Effluent DEL*** $(Bq \cdot a^{-1})$	***Emission (Bq)***	***Liquid Effluent DEL*** $(Bq \cdot a^{-1})$	***Emission (Bq)***
I-125	-----------		2.3E+14	
I-129	-----------		1.9E+13	
I-131	2.2E+13		3.0E+14	
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18		-----------	
Xe-133	2.4E+18	1.6E+12	-----------	
Xe-133m	2.8E+18		-----------	
Xe-135	3.4E+17	9.1E+11	-----------	
Xe-135m	2.0E+17	9.1E+09	-----------	
Xe-137	-----------	6.3E+09	-----------	
Xe-138	2.2E+16	1.2E+10	-----------	
Cs-134	1.9E+13		2.5E+14	
Cs-135	-----------		3.4E+15	
Cs-136	-----------		6.3E+14	
Cs-137	5.4E+12		4.0E+14	4.1E+06
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	
Ce-144	1.1E+14		2.8E+14	
Np-239	1.0E+16		-----------	
Noble Gas	7.3E+16 (Bq-MeV)		-----------	
Sn-113	-----------		-----------	1.4E+05
Gd-153	-----------		-----------	3.5E+08
Gd-159	-----------		-----------	1.4E+08
Tb-160	-----------		-----------	3.9E+07
W-187	-----------		-----------	4.0E+05
Np-239	-----------		-----------	7.3E+05
Alpha	-----------		-----------	2.9E+07
Beta	-----------		-----------	1.6E+08

Emissions from some locations require the use of a different DEL to compensate for flow rates.

3 Sample Media, Locations and Frequencies

The data contained in this report are for samples collected from January 1 to December 31, 2005, with some overlap for air, precipitation and TLD samples. During this time, the major media analysed and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place at least once each week throughout the year. The number of each sample type and the major radionuclide measurements performed are listed in Table 3.02.

The miscellaneous sample group includes those that do not fit into any of these listed categories or are not routinely collected. These include numerous in-station samples (e.g., drinking water) relating to the operation of PLGS.

The major sample locations are listed in Table 3.03 (details in Appendix C) and shown in Figures 3.02 to 3.05. Each "Indicator" site has a three or four-character identification code (e.g., F01, I10A). An Indicator site is one within the possible influence of PLGS emissions. “Reference” locations, chosen to lie outside the influence of PLGS emissions, are identified by the letter R at the end of the location code (e.g., A01R).

Sample locations for mobile seafood species (lobster, fish, etc.) caught in the Point Lepreau area are specified as accurately as reasonably possible. The location of capture, however, may bear little relationship to where the animal has been in the recent past. The availability of such samples is not generally predictable and is outside of the control of the laboratory.

Table 3.01: Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Atmospheric Sampling	
Airborne Particulates	Monthly (integrated sample)
Airborne Iodines	Monthly (integrated sample)
Water Vapour	Monthly (integrated sample)
Carbon Dioxide	Monthly (integrated sample)
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
GEM Particulates	Weekly Composite (integrated sample)
Terrestrial Sampling	
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
Milk - commercial dairy - dairy farms	Monthly Quarterly
Well Water	Semi-annually
Pond, Puddle and Surface Water	Quarterly
Berries	Weekly in Season
Garden Vegetables	Weekly in Season
Vegetation	Monthly
Soil	Quarterly
Monitoring Well Water (Near Plant)	Annually
Precipitation	Monthly (integrated sample)
Marine Sampling	
Seawater	Quarterly
Clams	Quarterly When Available
Fish	Quarterly When Available
Lobster	Quarterly When Available
Periwinkles	Monthly When Available
Aquaculture Salmon	Quarterly When Available
Scallops	Quarterly When Available
Crabs	Quarterly When Available
Dulse	Monthly When Available
Other Sea Plants	Quarterly
Sediment	Quarterly
Ambient Gamma Measurements of Intertidal Zone (Ion Chamber)	Quarterly
LEM Composite Water	Monthly Composite (integrated sample)

Table 3.01 (continued): Schedule of Sample Collection and Analysis

Sample Medium	***Typical Frequency***
Solid Radioactive Waste Management Facility	
Bore Hole Water	Three Times Per Year
Parshall Flume Water	Weekly
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
Hemlock Knoll Regional Sanitary Landfill	
Monitoring Well Water	Annually
Water (leachate and settling/holding ponds)	Monthly to Semi-annually
Ambient Gamma Measurements (TLDs))	Quarterly (integrated sample)

Table 3.02: Sample Information

Sample Medium	***Number of Samples***	***Radionuclide Measurements***
Atmospheric Sampling		
Airborne Particulates	96	gamma emitters & gross alpha/beta
Airborne Iodines	96	Iodine-130,131,132,133,135
Water Vapour	96	Tritium
Carbon Dioxide	36	Carbon-14
Ambient Gamma Measurements (TLDs)*	126*	gamma exposure
GEM Particulates	52	Strontium-89,90 & gamma emitters
Terrestrial Sampling		
Ambient Gamma Measurements (TLDs)*	126*	gamma exposure
Milk - commercial dairy - dairy farms	12 12	gamma emitters & tritium
Well Water	32	gamma emitters, gross alpha/beta & tritium
Pond, Puddle and Surface Water	31	gamma emitters & tritium
Berries	5	gamma emitters
Garden Vegetables	24	gamma emitters
Vegetation	15	gamma emitters
Soil	36	gamma emitters
Monitoring Well Water (Near Plant)	24	gamma emitters &
Precipitation	48	gamma emitters & tritium
Marine Sampling		
Seawater	16	gamma emitters & tritium
Clams	7	gamma emitters
Fish	0	gamma emitters
Lobster	6	gamma emitters
Periwinkles	10	gamma emitters
Aquaculture Salmon	4	gamma emitters
Scallops	0	gamma emitters
Crabs	0	gamma emitters
Dulse	12	gamma emitters
Other Sea Plants	12	gamma emitters
Sediment	40	gamma emitters
Ambient Gamma Measurements of Intertidal Zone (Ion Chamber)	40	gamma exposure
LEM Composite Water	14	Strontium-89,90, gamma emitters, gross alpha/beta

*The same TLD measures gamma dose from radionuclides in the air and on the ground.

Table 3.02 (continued): Sample Information

Sample Medium	***Number of Samples***	***Radionuclide Measurements***
Solid Radioactive Waste Management Facility		
Bore Hole Water	68	gamma emitters & tritium
Parshall Flume Water	104	gamma emitters & tritium
Ambient Gamma (TLDs)	148	gamma exposure
Hemlock Knoll Regional Sanitary Landfill		
Monitoring Well Water	32	gamma emitters & tritium
Water (leachate and settling/holding ponds)	22	gamma emitters & tritium
Ambient Gamma (TLDs)	16	gamma exposure
Other		
Miscellaneous	92	as required
Quality Assurance	230	as scheduled

Table 3.03: General Location Codes

Code	*Location*
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site – northeast quadrant
J	PLGS site – southeast quadrant
K	PLGS site – southwest quadrant
L	PLGS site – northwest quadrant
M	PLGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

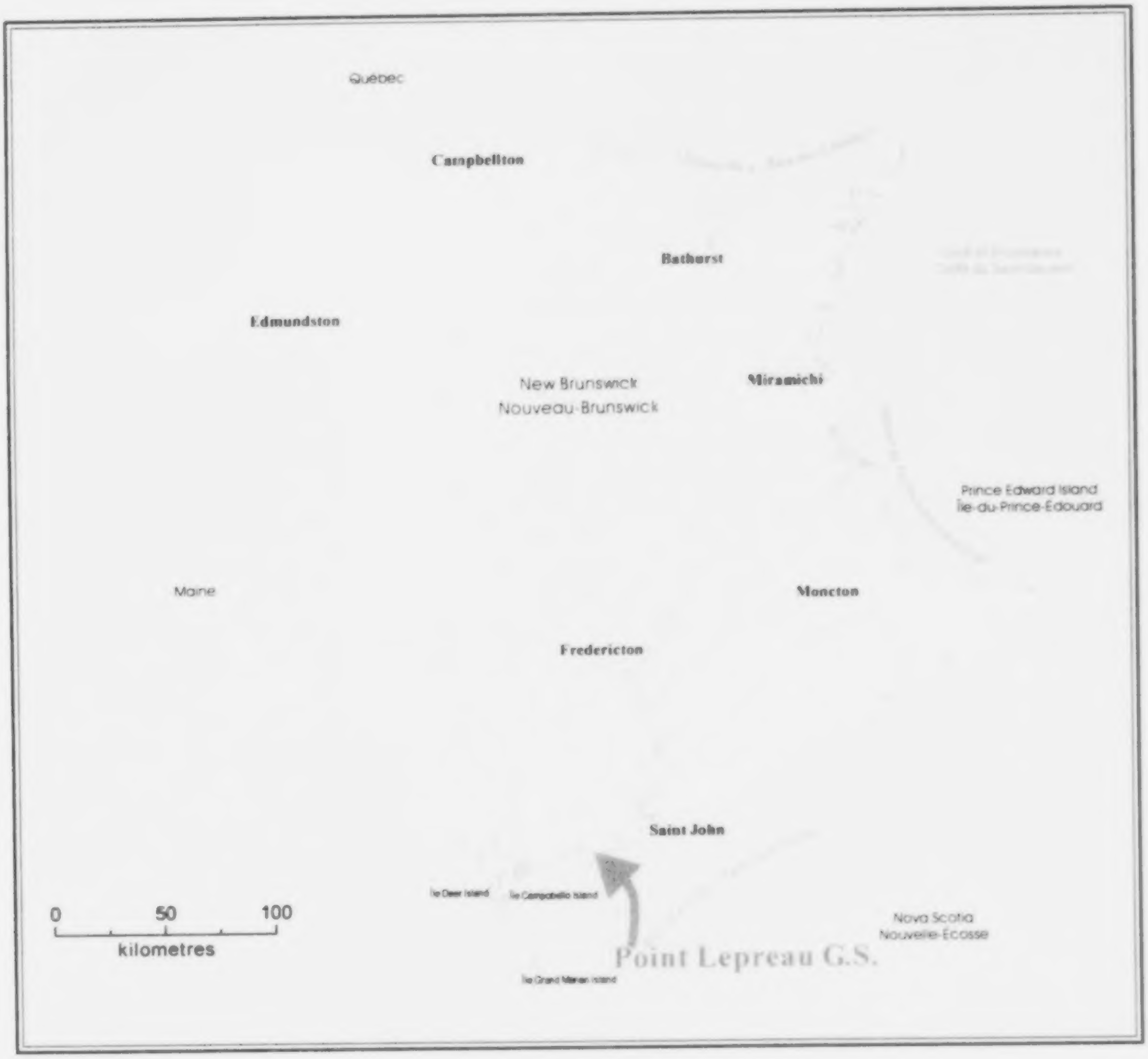

Québec
Campbellton
Bathurst
Edmundston
New Brunswick
Nouveau-Brunswick
Miramichi
Prince Edward Island
Île-du-Prince-Édouard
Maine
Moncton
Fredericton
Saint John
Île Deer Island
Île Campobello Island
0
50
100
kilometres
Point Lepreau G.S.
Nova Scotia
Nouvelle-Écosse
Île Grand Manan Island

Figure 3.01: Map of New Brunswick

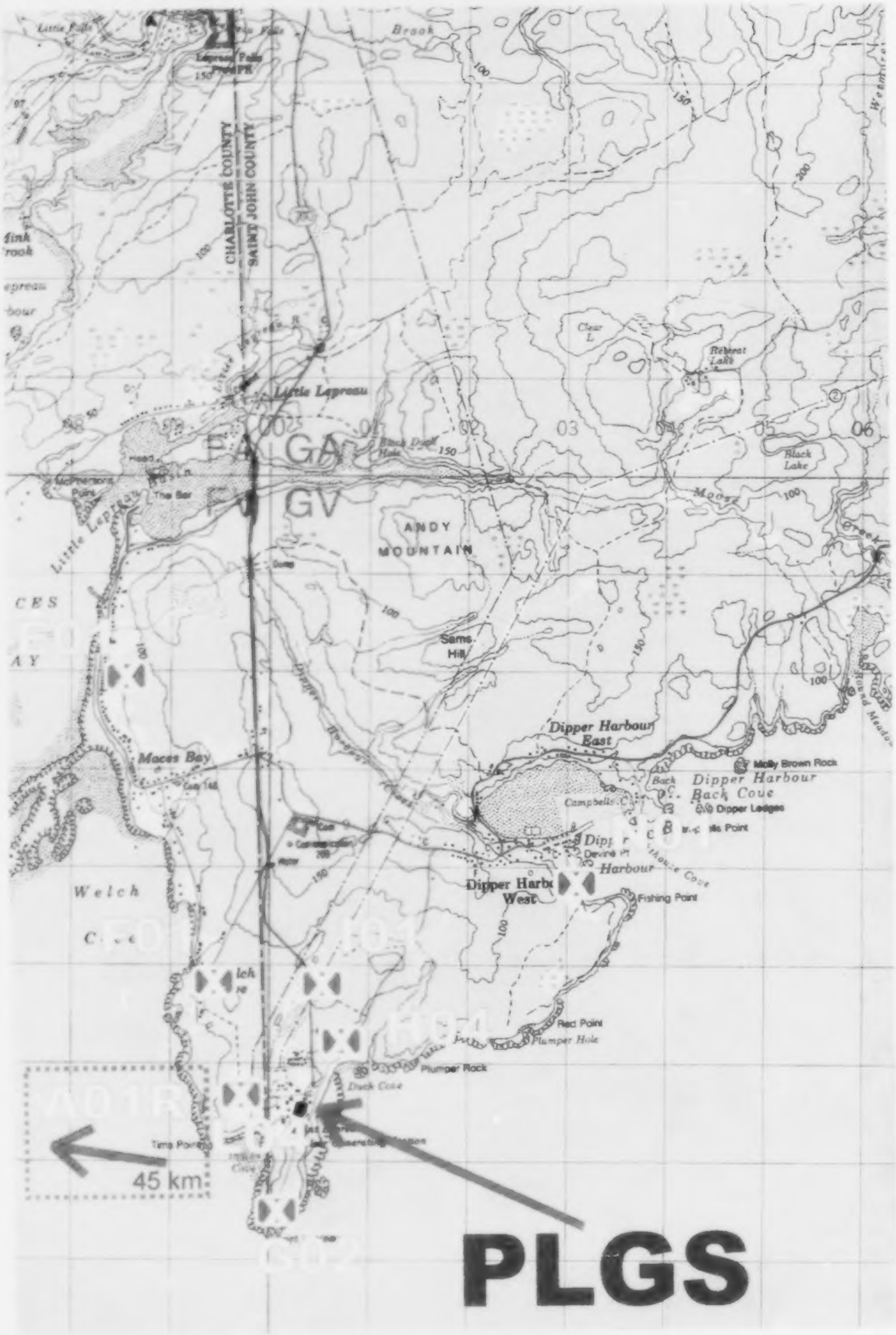

CHARLOTTE COUNTY
SAINT JOHN COUNTY
Little Lepreau
FA GA
FV GV
02
03
04
05
06
ANDY MOUNTAIN
Sams Hill
Black Lake
Clear L
Retreat Lake
Maces Bay
Welch Cove
Dipper Harbour East
Dipper Harbour Back Cove
Molly Brown Rock
Dipper Ledges
Campbells C.
Dipper Harbour
Dipper Harbour West
Fishing Point
Red Point
Plumper Hole
Plumper Rock
Duck Cove
Tims Point
F01
I01
H04
A01R
45 km
PLGS

Figure 3.02: Air Monitoring Stations

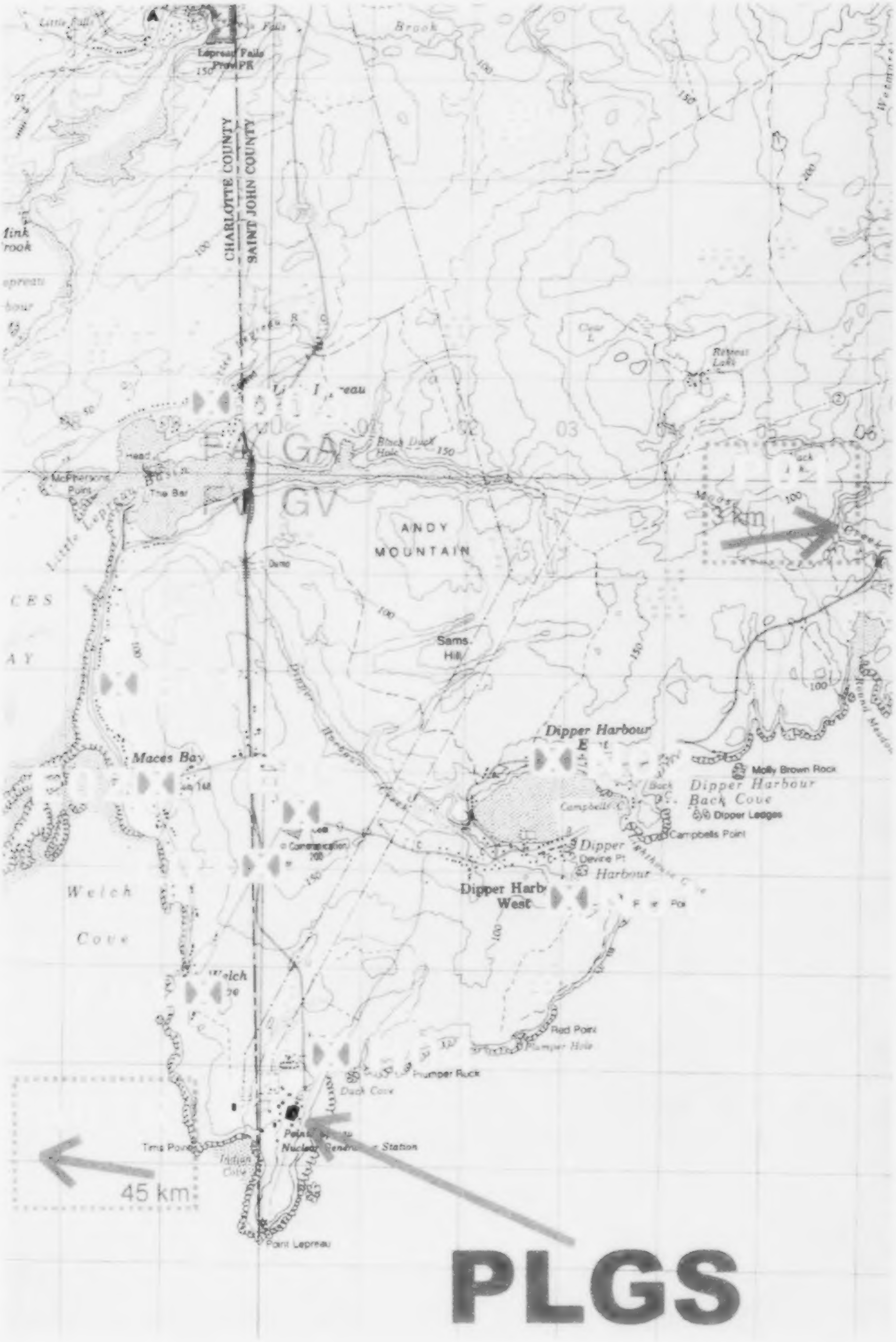

Lepreau Falls Prov PK
CHARLOTTE COUNTY
SAINT JOHN COUNTY
Little Lepreau
Black Duck Hole
McPherson Point
The Bar
ANDY MOUNTAIN
Sams Hill
Maces Bay
Dipper Harbour East
Dipper Harbour Back Cove
Molly Brown Rock
Dipper Ledges
Campbells Point
Dipper Harbour
Dipper Harbour West
Welch Cove
Red Point
Pumper Rock
Duck Cove
Tims Point
Indian Cove
Point Lepreau Nuclear Generating Station
Point Lepreau
3 km
45 km
PLGS

Figure 3.03: Well Water Sites

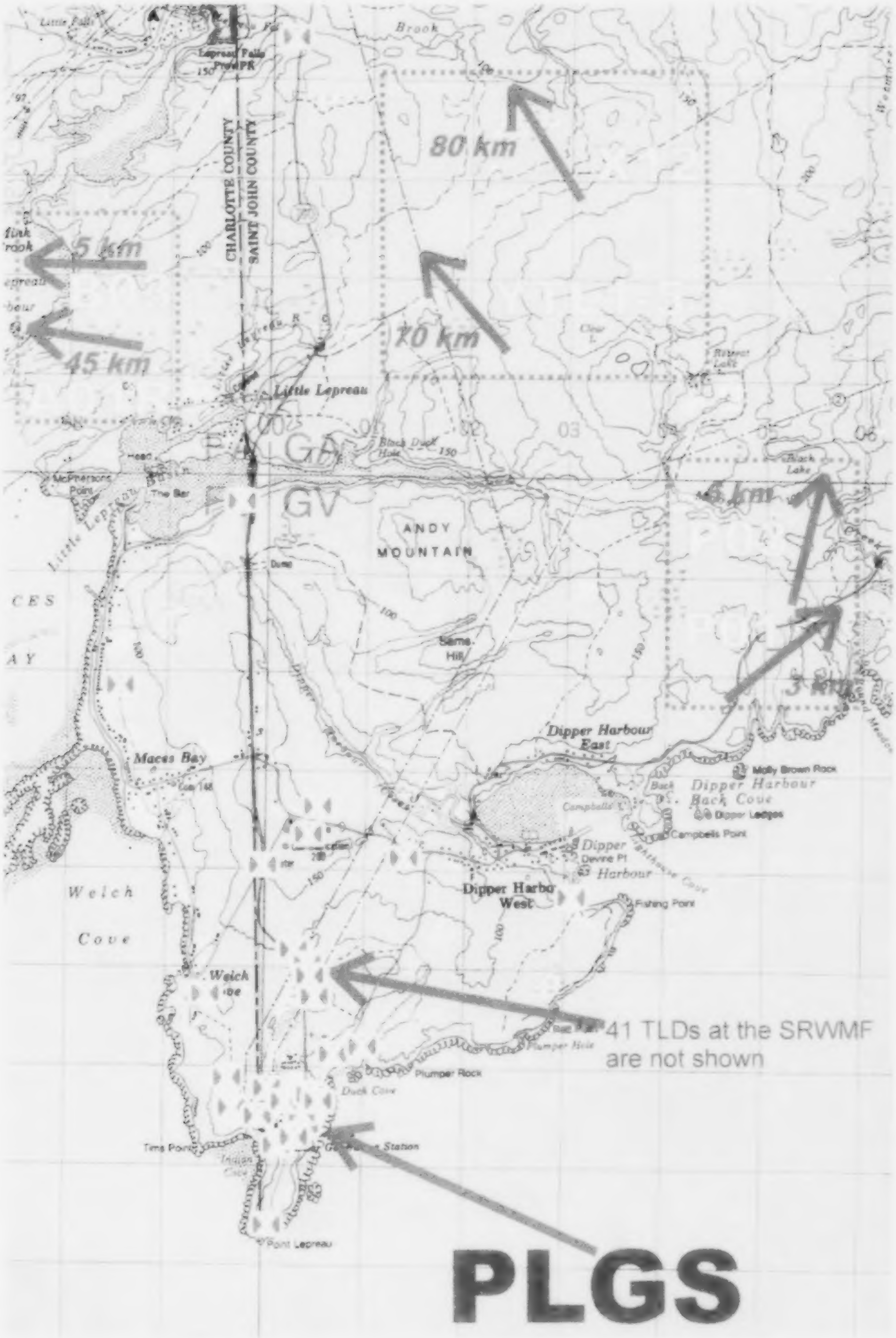

80 km
5 km
45 km
70 km
4 km
3 km
41 TLDs at the SRWMF are not shown
PLGS
Little Lepreau
ANDY MOUNTAIN
Maces Bay
Welch Cove
Dipper Harbour East
Dipper Harbour West
Point Lepreau
CHARLOTTE COUNTY
SAINT JOHN COUNTY

Figure 3.04: TLD Sites

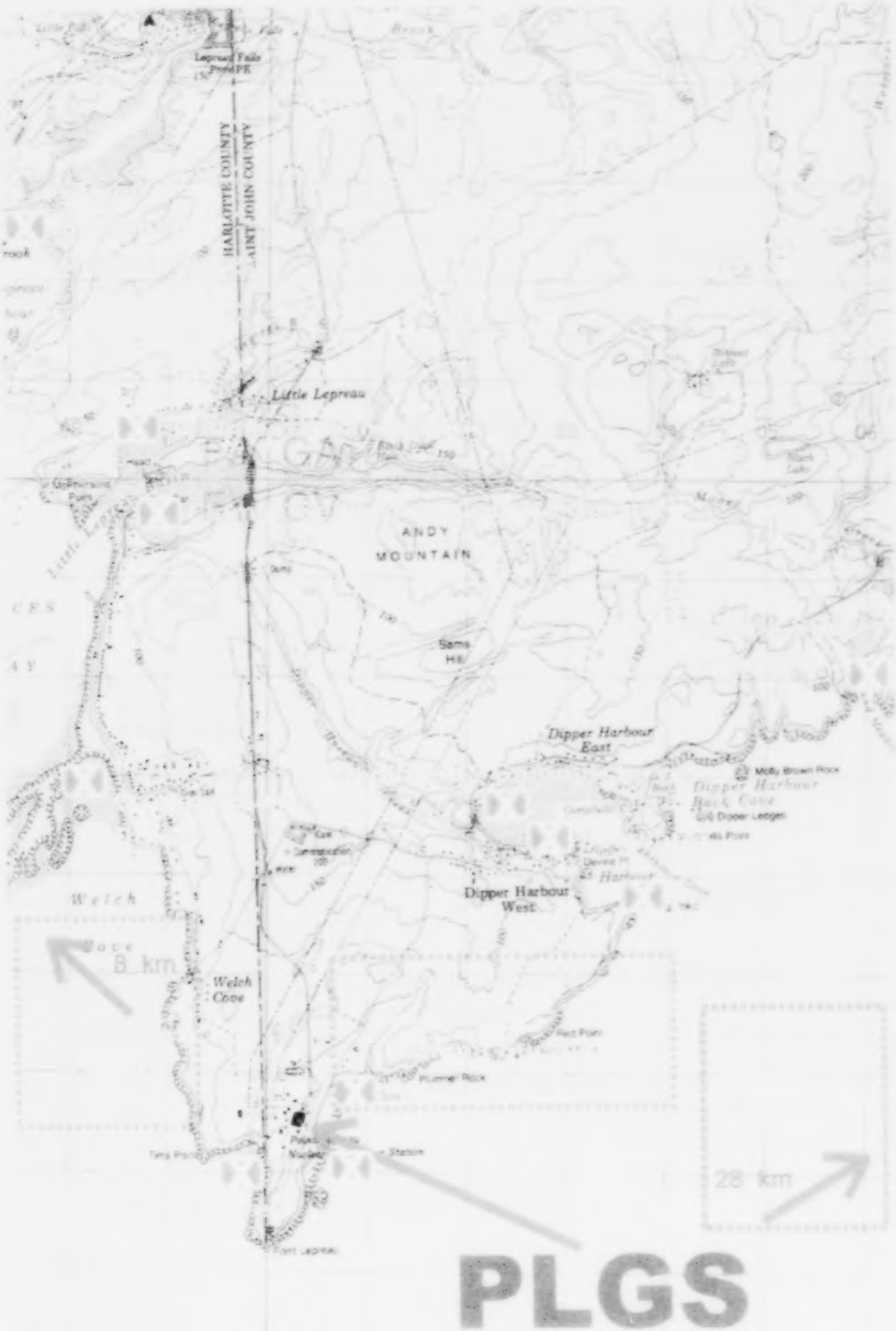

CHARLOTTE COUNTY
SAINT JOHN COUNTY
Little Lepreau
ANDY MOUNTAIN
Sams Hill
Dipper Harbour East
Dipper Harbour Back Cove
Molly Brown Rock
Dipper Ledges
Dipper Harbour West
Welch Cove
Red Point
Plumper Rock
Point Lepreau
8 km
28 km
PLGS

Figure 3.05: Marine Monitoring Sites

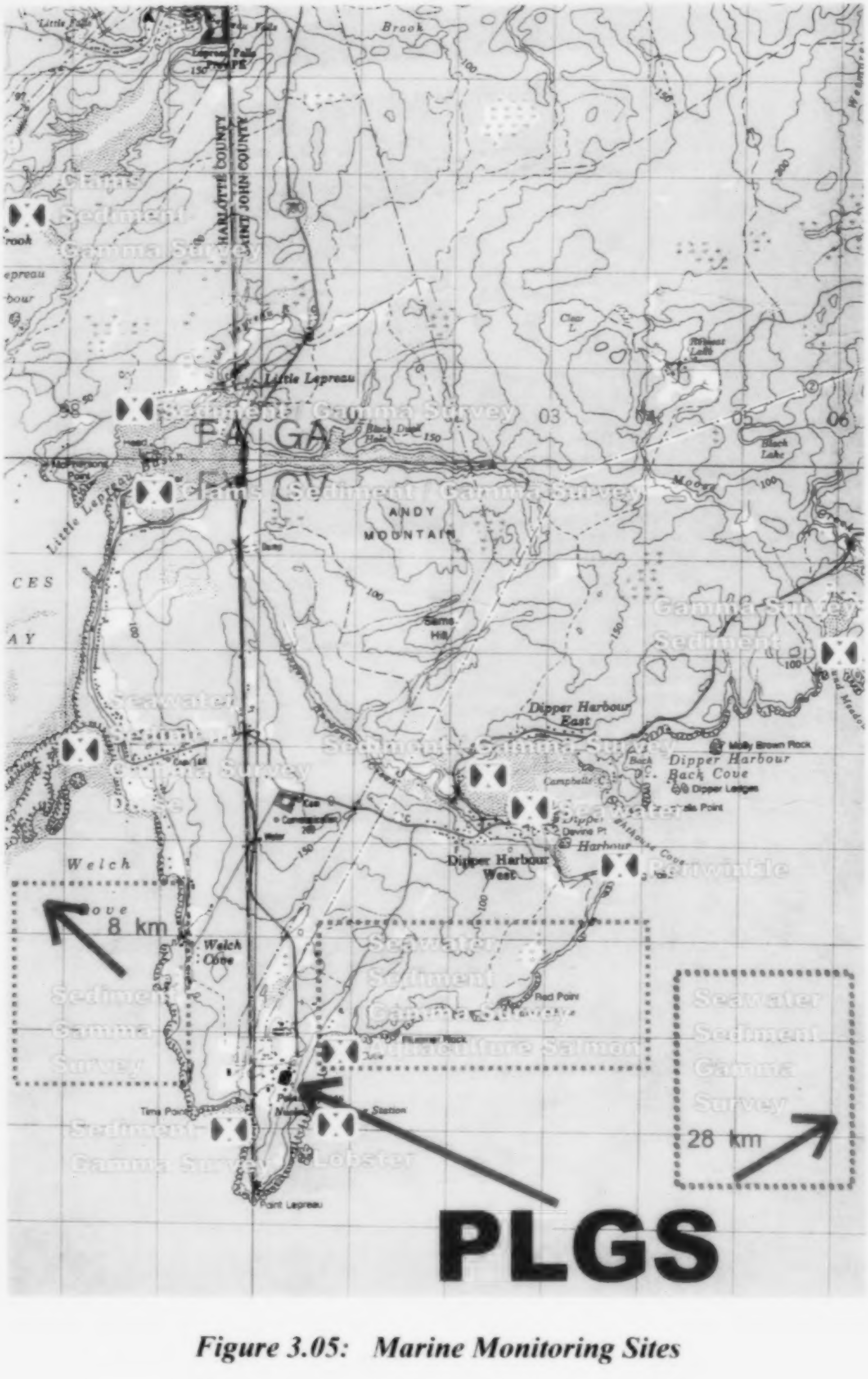

Clams
Sediment
Gamma Survey
Little Lepreau
Sediment / Gamma Survey
03
04
05
06
Black Lake
Clams / Sediment / Gamma Survey
ANDY MOUNTAIN
Gamma Survey
Sediment
Seawater
Sediment
Gamma Survey
House
Sediment / Gamma Survey
Dipper Harbour East
Molly Brown Rock
Dipper Harbour Back Cove
Dipper Ledges
Seawater
Dipper Harbour West
Periwinkle
Welch Cove
8 km
Sediment
Gamma
Survey
Seawater
Sediment
Gamma Survey
Aquaculture Salmon
Red Point
Seawater
Sediment
Gamma
Survey
28 km
Sediment
Gamma Survey
Lobster
Point Lepreau
PLGS

Figure 3.05: Marine Monitoring Sites

4 Summary and Discussion of Data

The following is a summary and discussion of the data on environmental samples collected for the year 2005.

Most samples contained detectable levels of naturally occurring K-40 or cosmogenically produced Be-7. Some contained Cs-137 (soils, sediments, lichen) from the atmospheric bomb tests of past years and the Chernobyl accident. Tritium (in air and fresh water) is the only radionuclide originating from PLGS that is detected consistently. In 2005, analyses that indicated emissions traceable to PLGS were:

- H-3 in airborne water vapour and fresh water
- TLD measurements at onsite locations
- H-3 in Parshall flume and bore hole water from the Solid Radioactive Waste Management Facility (SRWMF)
- H-3 in water from onsite monitoring wells

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. Offsite, the activity of H-3 in air ranges from less than about 2E-02 $Bq{\cdot}m^{-3}$ (below the lower limit of detection by the method used) to about 2E+00 $Bq{\cdot}m^{-3}$ of air. The natural concentration of H-3 is up to 7E-01 $Bq{\cdot}L^{-1}$ in most surface waters and up to 1E-03 $Bq{\cdot}m^{-3}$ in air.

The natural concentration of C-14 in the atmosphere is approximately 4E-2 $Bq{\cdot}m^{-3}$. This level is usually detected by the sensitive analytical method used in the monitoring program.

Only detected radionuclides are listed in the following tables. Refer to Tables A.01 to A.11 in Appendix A for detailed listings of detection limits. Refer to Appendix C for a listing of location codes. Most tables contain the following data:

Column 1 - Shows the type of analysis or nuclide.

Column 2 - Shows the total number of samples analysed.

Column 3 – Shows the mean of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 4 - Shows the range of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 5 - Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator stations.

Column 6 - Shows the ratio of the number of detected values to the total number of Indicator samples.

Column 7 - Shows the range of detected values for the Indicator stations.

Column 8 - Shows the mean of detected values at the Reference location(s).

Column 9 - Shows the ratio of detected values to the total number of samples at this location.

Column 10 - Shows the range of detected values for the Reference location(s).

4.01 Airborne Particulates

Of the 96 filters analysed, Be-7 was detected on 86, gross alpha was detected on 92, gross beta was detected on 96 and K-40 on one. None of these are attributable to the operation of PLGS.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the filters are changed and analysed. There were no collection days lost due to equipment failure.

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring radon progeny, cosmogenic (Be-7), and man-made sources of radiation. The maximum concentration of gross beta in air onsite was 3.5E-04 $Bq{\cdot}m^{-3}$ of air. Offsite it reached 3.2E-04 $Bq{\cdot}m^{-3}$.

When Sr-89,90 emissions are low, the expected concentration in environmental air samples is below the detection limit. The GEM monitors PLGS gaseous emissions continuously at their source. The GEM filter is changed daily and the weekly composite is sent to the lab for analysis. Fifty-two sets of these GEM filters were analysed for Sr-89,90. If the emission rate is more than 1% DEL, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples. Since no Sr-89 emissions were detected in 2005 and Sr-90 average emissions were 2E-8% DEL (and at no time exceeded 1% DEL), no further analyses were required.

Table 4.01 is a summary of detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location throughout the year. There is a slight seasonal trend in the data.

Table 4.01: Airborne Particulates (Bq·m^{-3})

Analysis Type	**Total Number**	**Critical Level**		**Indicator Locations**			**Reference Locations**		
		Mean	**Range**	**Mean**	**Frequency**	**Range**	**Mean**	**Frequency**	**Range**
Alpha	96	3.4E-6	1.2E-6 to 1.7E-5	1.5E-5	80/84	4.5E-6 to 3.2E-5	1.4E-5	12/12	9.5E-6 to 2.6E-5
Beta	96	7.0E-6	2.8E-6 to 3.1E-5	1.5E-4	84/84	4.1E-5 to 3.3E-4	1.5E-4	12/12	8.0E-5 to 2.9E-4
Be-7	96	2.4E-4	3.2E-5 to 1.4E-3	1.2E-3	74/84	2.7E-4 to 2.3E-3	1.1E-3	12/12	2.9E-4 to 1.9E-3
K-40	96	5.3E-4	1.6E-4 to 2.7E-3	3.1E-4	1/84	3.1E-4 to 3.1E-4	*	*	*

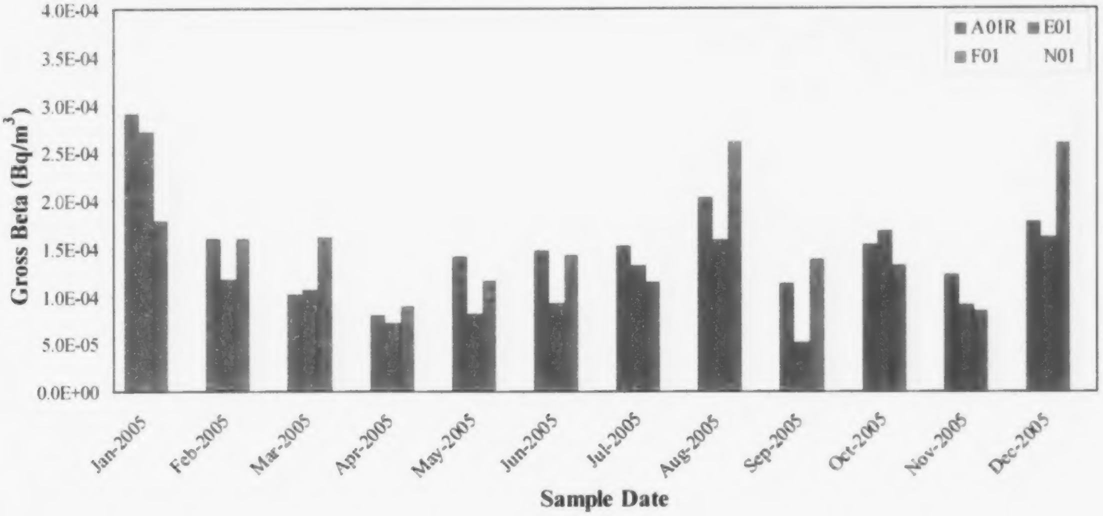


Figure 4.01: Gross Beta (Air Particulates) at Each Offsite Air Station

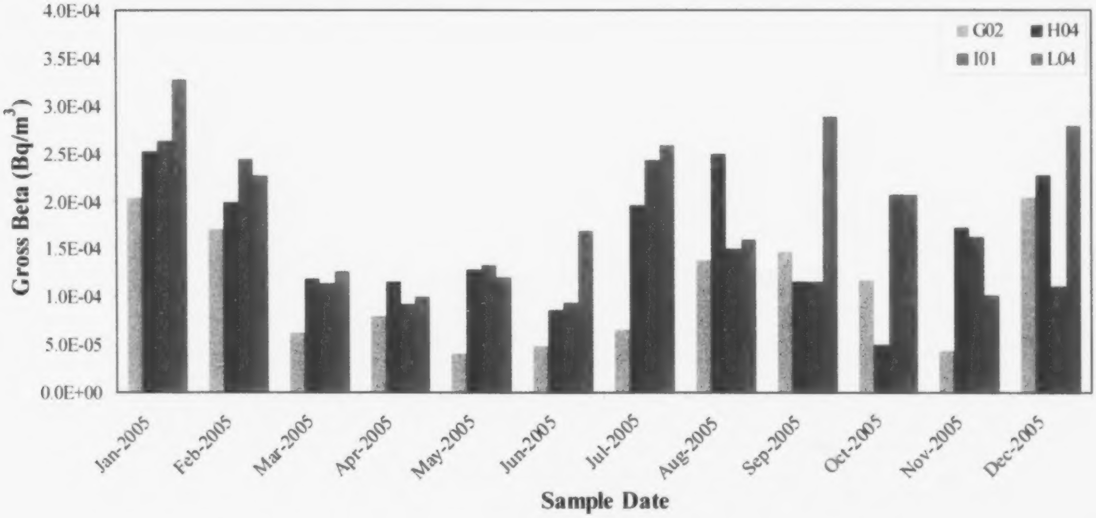


Figure 4.02: Gross Beta (Air Particulates) at Each Onsite Air Station

4.02 Airborne Iodines

No radioiodines were detected in any of the 96 samples analysed.

Air is monitored continuously, using charcoal cartridges, from the eight locations shown in Figure 3.02. Once a month the cartridges are changed and analysed. There were no collection days lost due to equipment failure.

Iodine-131 was consistently below the Critical Level (average 6.9E-06 $Bq \cdot m^{-3}$).

4.03 Water Vapour

Tritium was detected in 77 of the 84 samples collected from the air monitoring stations on the Point Lepreau peninsula, and was detected in one of the 12 samples at the reference location.

Water vapour is collected continuously in molecular sieve bombs from the eight locations shown in Figure 3.02. Once a month the bombs are changed and analysed. There were no collection days lost due to equipment failure.

The maximum concentration of tritium in air onsite was 3.9E+00 $Bq \cdot m^{-3}$ of air. Offsite it reached 1.8E+00 $Bq \cdot m^{-3}$. Tritium has been detected from time to time at the reference location, even before PLGS became operational.

Table 4.02 is the summary table of the tritium data and Table 4.03 gives details of the tritium results by location. Figures 4.03 and 4.04 show the H-3 results for each location. "Less Than" values are plotted for non-detected results. Generally, locations to the northeast (H04, I01 and N01) have elevated H-3 measurements in the warmer months due to the predominant summer wind direction, which changes in the winter to impact the southwest locations (G02 and L04).

When H-3 emissions are low, the expected concentration in other environmental samples is below the detection limit. If the H-3 emission rate is more than 1% DEL, a H-3 analysis is performed on berries and garden vegetables. Since the average emission rate in 2005 was 4E-02% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.05 shows the weekly H-3 emissions and Figure 4.06 compares the emissions with the environmental air monitoring results.

Table 4.02: Water Vapour (Bq·m^{-3})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	96	5.6E-2	9.9E-3 to 2.6E-1	8.0E-1	77/84	1.6E-2 to 3.9E+0	8.3E-2	1/12	8.3E-2 to 8.3E-2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.02: Water Vapour (Bq·m^{-3})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	96	5.6E-2	9.9E-3 to 2.6E-1	8.0E-1	77/84	1.6E-2 to 3.9E+0	8.3E-2	1/12	8.3E-2 to 8.3E-2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.03: Water Vapour H-3 at Each Air Station (Bq·m^{-3})

Location Code		***A01R***	***E01***	***F01***	***G02***	***H04***	***I01***	***L04***	***N01***
Location		***Bocabec***	***Maces Bay***	***Welch Cove***	***Lepreau Lighthouse***	***Former Information Centre Site***	***SRWMF***	***Construction Stores***	***Dipper Harbour***
Distance from PLGS		***45 km***	***4.5 km***	***1.6 km***	***1.0 km***	***0.75 km***	***1.2 km***	***0.55 km***	***3.7 km***
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2005-01-05	<2.4E-2	2.8E-2	1.2E-1	9.7E-1	3.4E-1	1.0E+0	8.1E-1	1.6E-2
	2005-02-08	<2.4E-2	2.9E-2	2.2E-1	4.9E-1	6.8E-1	7.9E-1	6.1E-1	6.7E-2
	2005-03-15	<2.8E-2	<5.2E-2	7.8E-2	1.1E+0	1.5E+0	1.2E+0	5.5E-1	8.1E-2
	2005-04-14	<3.8E-2	<7.6E-2	7.2E-2	1.4E-1	1.0E+0	1.4E+0	3.5E-1	1.0E-1
	2005-05-24	<1.1E-1	<1.1E-1	1.3E-1	1.8E-1	1.1E+0	2.0E+0	8.2E-1	5.5E-2
	2005-06-16	<7.9E-2	<1.6E-1	2.8E-1	2.0E-1	2.0E+0	2.1E+0	1.5E+0	8.6E-2
	2005-07-17	8.3E-2	2.2E-1	4.2E-1	1.2E-1	1.1E+0	2.2E+0	1.5E-1	4.0E-1
	2005-08-18	<1.4E-1	1.9E-1	3.0E-1	3.1E-1	5.9E-1	1.5E+0	4.3E-1	6.3E-1
	2005-09-14	<8.2E-2	2.8E-1	1.3E-1	2.9E-1	3.9E+0	2.7E+0	2.0E-1	3.9E-1
	2005-10-12	<6.4E-2	<7.4E-2	<1.1E-1	5.2E-1	1.2E+0	1.9E+0	2.8E+0	9.7E-2
	2005-11-08	<2.6E-2	6.1E-1	1.8E+0	8.0E-1	1.5E+0	2.0E+0	2.5E+0	1.5E-1
	2005-12-07	<1.9E-2	<1.2E-1	2.1E-1	8.0E-1	1.4E+0	1.1E+0	1.3E+0	4.4E-2

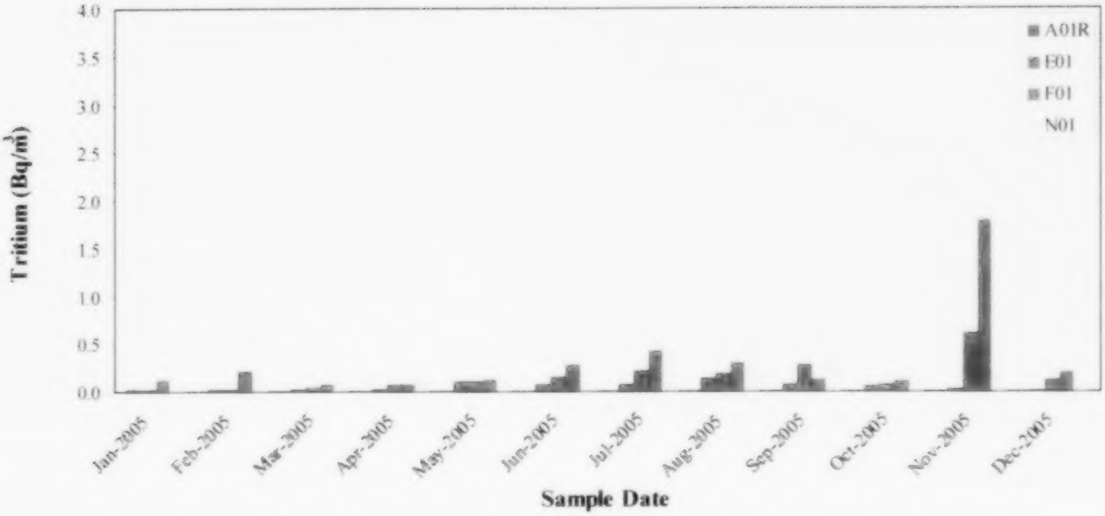


Figure 4.03: Tritium (Water Vapour) at Each Offsite Air Station

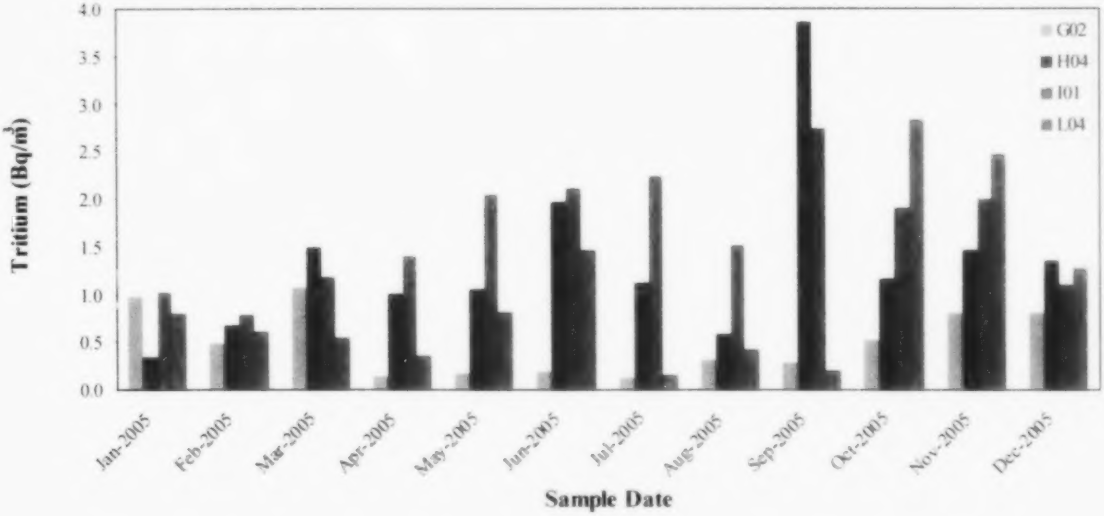
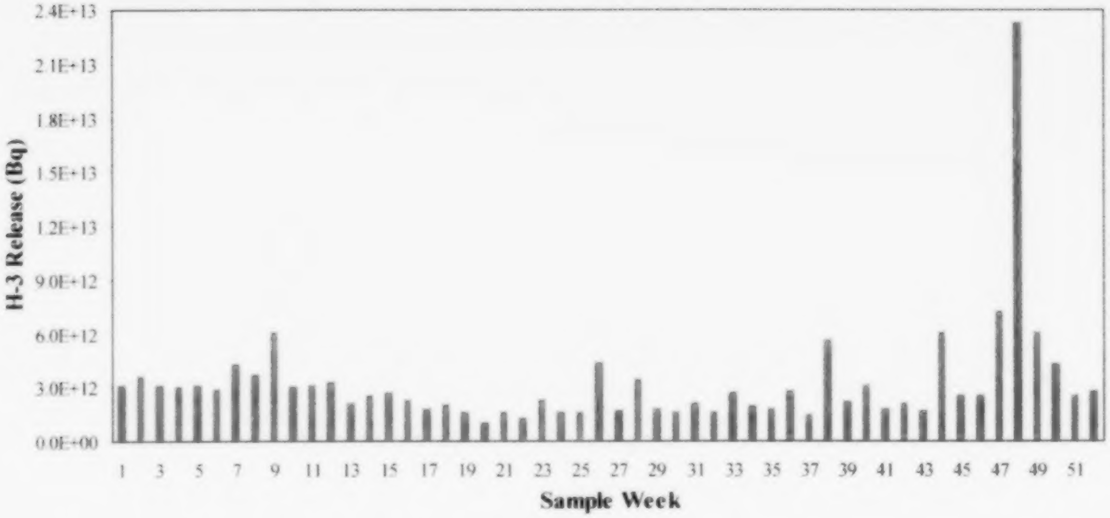


Figure 4.04: Tritium (Water Vapour) at Each Onsite Air Station



Note: The DEL for H-3 is 4.3E+17 Bq a^{-1}

Figure 4.05: Gaseous H-3 Emissions

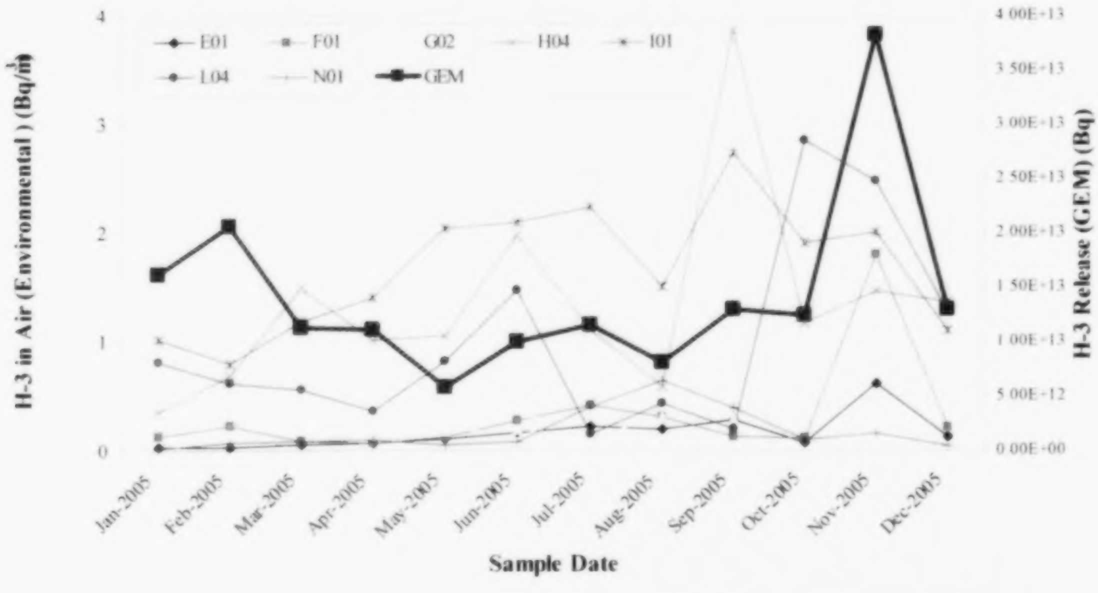


Figure 4.06: Gaseous H-3 Emissions and H-3 (Water Vapour) Results

4.04 Carbon Dioxide

Carbon-14 was detected in 23 of the 24 samples from the onsite monitors and 12 of the 12 samples from the offsite monitor.

Air is continuously bubbled through a caustic solution at two onsite locations (G02 and H04 in Figure 3.02) and one reference location. The caustic bubblers are changed monthly and returned to the lab for analysis.

The maximum concentration of C-14 in air onsite was 6.7E-02 $Bq{\cdot}m^{-3}$ of air. Offsite it reached 5.2E-02 $Bq{\cdot}m^{-3}$. The results for the two onsite monitors (mean of 4.4E-02 $Bq{\cdot}m^{-3}$) were similar to the reference monitor (mean of 3.8E-02 $Bq{\cdot}m^{-3}$). Based on stack emissions, the calculated average annual concentration of C-14 in air at the boundary fence for 2005 was less than 2E-03 $Bq{\cdot}m^{-3}$ (well below the natural level of 4E-02 $Bq{\cdot}m^{-3}$).

Individual analysis results are given in Table 4.04 by location (graphically shown in Figure 4.07). Table 4.05 gives details of C-14 results.

When C-14 emissions are low, the expected concentration in other environmental samples is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on berries, milk, water and garden vegetables. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions and Figure 4.09 compares the emissions with the environmental air monitoring results.

Table 4.04: Carbon Dioxide (Bq·m^{-3})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
C-14	36	2.1E-2	1.9E-2 to 3.1E-2	4.4E-2	23/24	2.3E-2 to 6.7E-2	3.8E-2	12/12	2.8E-2 to 5.2E-2

Table 4.04: Carbon Dioxide (Bq·m^{-3})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
C-14	36	2.1E-2	1.9E-2 to 3.1E-2	4.4E-2	23/24	2.3E-2 to 6.7E-2	3.8E-2	12/12	2.8E-2 to 5.2E-2

Table 4.05: Carbon Dioxide C-14 at Each Monitoring Location (Bq·m^{-3})

Location Code		***G02***	***H04***	***X03R***
Location		***Lepreau Lighthouse***	***Former Information Centre Site***	***Fredericton Laboratory***
Distance from PLGS		***1.0 km***	***0.75 km***	***100 km***
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2005-01-05	4.7E-2	3.5E-2	2.8E-2
	2005-02-08	4.1E-2	5.0E-2	3.3E-2
	2005-03-15	5.4E-2	4.4E-2	5.2E-2
	2005-04-14	2.3E-2	4.4E-2	3.0E-2
	2005-05-24	2.3E-2	5.2E-2	4.2E-2
	2005-06-16	6.4E-2	4.4E-2	3.9E-2
	2005-07-13	3.8E-2	4.4E-2	3.7E-2
	2005-08-18	<3.8E-2	4.6E-2	4.0E-2
	2005-09-14	4.4E-2	6.7E-2	3.6E-2
	2005-10-12	4.3E-2	4.6E-2	5.1E-2
	2005-11-08	3.8E-2	4.6E-2	3.9E-2
	2005-12-07	3.4E-2	5.3E-2	3.3E-2

Table 4.05: Carbon Dioxide C-14 at Each Monitoring Location ($Bq\cdot m^{-3}$)

Location Code		***G02***	***H04***	***X03R***
Location		***Lepreau Lighthouse***	***Former Information Centre Site***	***Fredericton Laboratory***
Distance from PLGS		***1.0 km***	***0.75 km***	***100 km***
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2005-01-05	4.7E-2	3.5E-2	2.8E-2
	2005-02-08	4.1E-2	5.0E-2	3.3E-2
	2005-03-15	5.4E-2	4.4E-2	5.2E-2
	2005-04-14	2.3E-2	4.4E-2	3.0E-2
	2005-05-24	2.3E-2	5.2E-2	4.2E-2
	2005-06-16	6.4E-2	4.4E-2	3.9E-2
	2005-07-13	3.8E-2	4.4E-2	3.7E-2
	2005-08-18	<3.8E-2	4.6E-2	4.0E-2
	2005-09-14	4.4E-2	6.7E-2	3.6E-2
	2005-10-12	4.3E-2	4.6E-2	5.1E-2
	2005-11-08	3.8E-2	4.6E-2	3.9E-2
	2005-12-07	3.4E-2	5.3E-2	3.3E-2

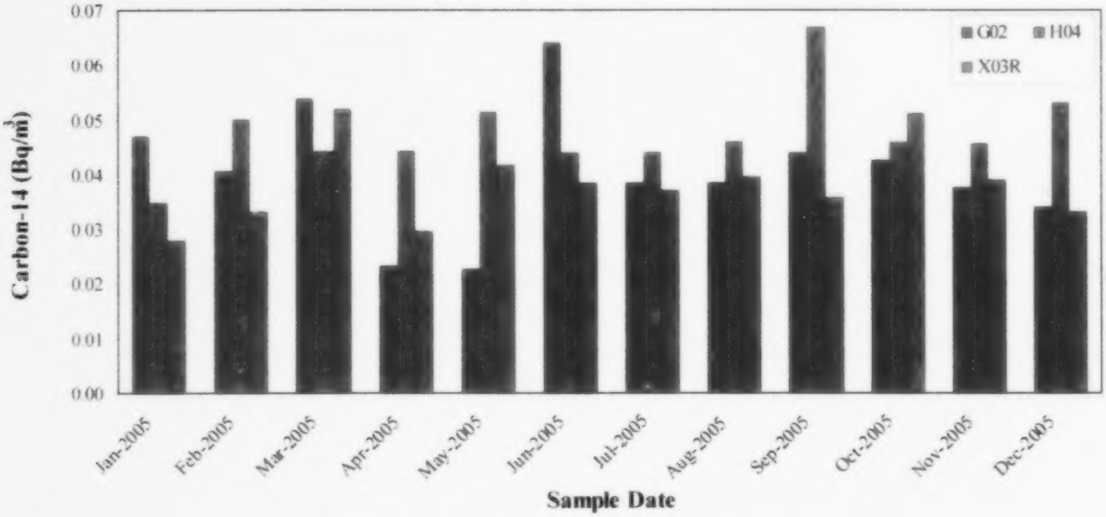
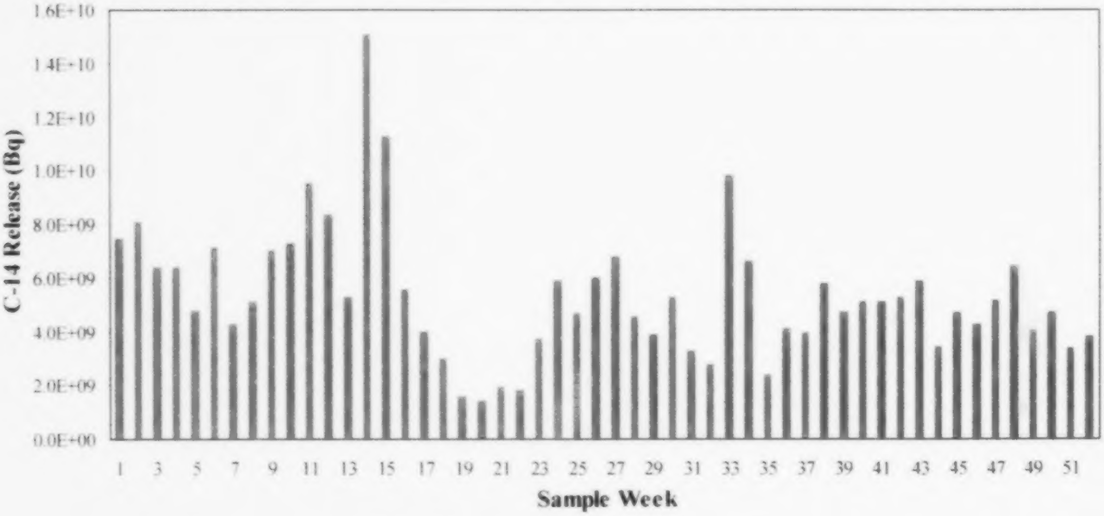


Figure 4.07: Carbon-14 (Carbon Dioxide)



Note: The DEL for C-14 is 3.3E+15 Bq a^{-1}

Figure 4.08: Gaseous C-14 Emissions

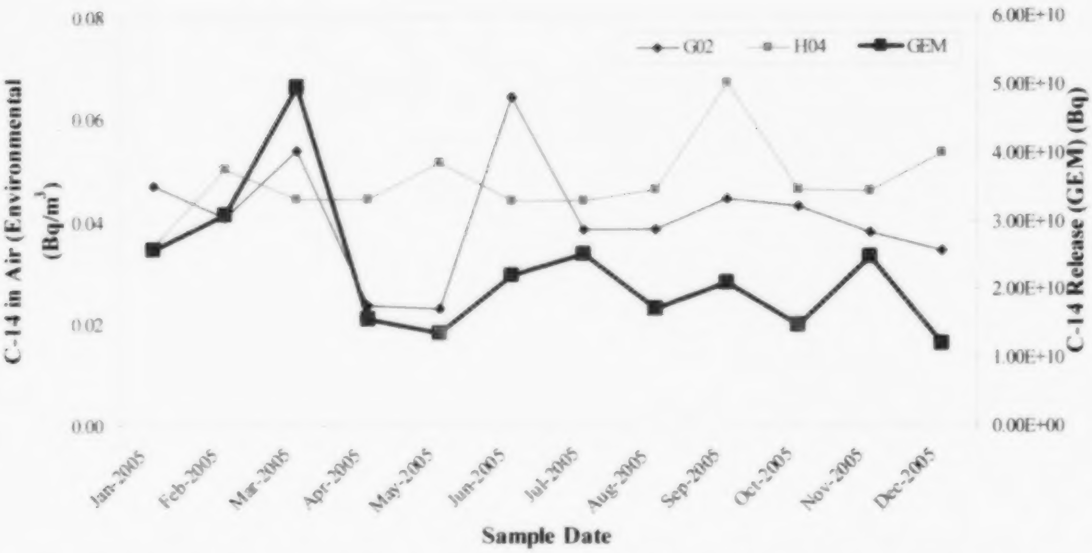


Figure 4.09: Gaseous C-14 Emissions and C-14 (Carbon Dioxide) Results

4.05 Ambient Gamma Measurements (TLD)

Gamma exposure measurements were slightly higher onsite, especially near the SRWMF and reactor building, than they were offsite.

Ambient gamma radiation is measured by TLDs at the 73 locations shown in Figure 3.04. Thirty seven of these are near the Solid Radioactive Waste Management Facility. TLDs are changed quarterly. Two of the 292 dosimeters placed in the environment were either lost or damaged.

The average for the SRWMF (884 μGy·a^{-1}) is slightly higher than for other onsite locations (742 μGy·a^{-1}) and boundary locations (615 μGy·a^{-1}). These other onsite locations are not significantly different from offsite locations (644 μGy·a^{-1}) and the reference location (590 μGy·a^{-1}). A new location was added in 2001 in a community remote from PLGS. The area is noted for its natural uranium content. The measurement there (1520 μGy·a^{-1}) is higher than any location at PLGS.

Data are given in Table 4.06. The locations J70 and M02, which are close to the reactor building and the air emissions stack, show higher levels of gamma radiation due to chronic emissions of low levels of noble gases. Increases at the SRWMF locations (I11A to I11L on the perimeter fence of the SRWMF-Phase 1 and I21A to I21L on the perimeter of the SRWMF-Phase 2) are due to low-level waste and used fuel emplacement, and not to station emissions. There is a small, but undefinable, component of radiation on the TLDs at the SRWMF that is due to enhanced natural radiation from the aggregate in the concrete structures. The results for the drop-off TLDs for SRWMF-Phase 2 are shown in Table 4.30. Figure 4.10 compares the reference location results with the results for other locations.

Table 4.06: Ambient Gamma – TLD (µGy)

Location	Dose (µGy± 10%)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
A01R	134 ± 13	150 ± 15	156 ± 16	149 ± 15	590 ± 30
B03	116 ± 12	170 ± 17	163 ± 16	156 ± 16	610 ± 30
C03	172 ± 17	223 ± 22	214 ± 21	220 ± 22	830 ± 40
D02	140 ± 14	179 ± 18	172 ± 17	169 ± 17	660 ± 30
E01	143 ± 14	144 ± 14	159 ± 16	137 ± 14	580 ± 30
E04	155 ± 15	182 ± 18	172 ± 17	172 ± 17	680 ± 30
E05	169 ± 17	155 ± 15	181 ± 18	138 ± 14	640 ± 30
E06	199 ± 20	194 ± 19	237 ± 24	165 ± 17	790 ± 40
F01	110 ± 11	123 ± 12	127 ± 13	116 ± 12	480 ± 20
G02	181 ± 18	216 ± 22	171 ± 17	165 ± 16	730 ± 40
H04	136 ± 14	147 ± 15	144 ± 14	134 ± 13	560 ± 30
H05	119 ± 12	112 ± 11	117 ± 12	114 ± 11	460 ± 20
I11A	207 ± 21	206 ± 21	242 ± 24	212 ± 21	870 ± 40
I11B	228 ± 23	203 ± 20	247 ± 25	227 ± 23	900 ± 50
I11C	209 ± 21	200 ± 20	237 ± 24	215 ± 22	860 ± 40
I11D	218 ± 22	180 ± 18	259 ± 26	221 ± 22	880 ± 40
I11E	198 ± 20	191 ± 19	243 ± 24	221 ± 22	850 ± 40
I11F	201 ± 20	204 ± 20	243 ± 24	212 ± 21	860 ± 40
I11G	199 ± 20	182 ± 18	233 ± 23	203 ± 20	820 ± 40
I11H	212 ± 21	214 ± 21	256 ± 26	226 ± 23	910 ± 50
I11I	210 ± 21	197 ± 20	239 ± 24	221 ± 22	870 ± 40
I11J	201 ± 20	192 ± 19	245 ± 25	208 ± 21	850 ± 40
I11K	216 ± 22	195 ± 20	222 ± 22	207 ± 21	840 ± 40
I11L	178 ± 18	177 ± 18	221 ± 22	201 ± 20	780 ± 40
I21A	193 ± 19	187 ± 19	224 ± 22	198 ± 20	800 ± 40
I21B	244 ± 24	219 ± 22	274 ± 27	230 ± 23	970 ± 50
I21C	180 ± 18	187 ± 19	228 ± 23	189 ± 19	780 ± 40
I21D	319 ± 32	308 ± 31	348 ± 35	327 ± 33	1300 ± 70
I21E	255 ± 25	347 ± 35	321 ± 32	275 ± 28	1200 ± 60
I21F	192 ± 19	187 ± 19	240 ± 24	208 ± 21	830 ± 40
I21G	239 ± 24	189 ± 19	249 ± 25	212 ± 21	890 ± 40
I21H	309 ± 31	217 ± 22	257 ± 26	240 ± 24	1020 ± 50
I21I	187 ± 19	183 ± 18	216 ± 22	177 ± 18	760 ± 40
I21J	201 ± 20	188 ± 19	202 ± 20	197 ± 20	790 ± 40
I21K	171 ± 17	182 ± 18	197 ± 20	222 ± 22	770 ± 40
I21L	198 ± 20	191 ± 19	219 ± 22	202 ± 20	810 ± 40

Table 4.06: Ambient Gamma – TLD (µGy)

Location	**Dose (µGy± 10%)**				
	1st Quarter	***2nd Quarter***	***3rd Quarter***	***4th Quarter***	***Year***
A01R	134 ± 13	150 ± 15	156 ± 16	149 ± 15	590 ± 30
B03	116 ± 12	170 ± 17	163 ± 16	156 ± 16	610 ± 30
C03	172 ± 17	223 ± 22	214 ± 21	220 ± 22	830 ± 40
D02	140 ± 14	179 ± 18	172 ± 17	169 ± 17	660 ± 30
E01	143 ± 14	144 ± 14	159 ± 16	137 ± 14	580 ± 30
E04	155 ± 15	182 ± 18	172 ± 17	172 ± 17	680 ± 30
E05	169 ± 17	155 ± 15	181 ± 18	138 ± 14	640 ± 30
E06	199 ± 20	194 ± 19	237 ± 24	165 ± 17	790 ± 40
F01	110 ± 11	123 ± 12	127 ± 13	116 ± 12	480 ± 20
G02	181 ± 18	216 ± 22	171 ± 17	165 ± 16	730 ± 40
H04	136 ± 14	147 ± 15	144 ± 14	134 ± 13	560 ± 30
H05	119 ± 12	112 ± 11	117 ± 12	114 ± 11	460 ± 20
I11A	207 ± 21	206 ± 21	242 ± 24	212 ± 21	870 ± 40
I11B	228 ± 23	203 ± 20	247 ± 25	227 ± 23	900 ± 50
I11C	209 ± 21	200 ± 20	237 ± 24	215 ± 22	860 ± 40
I11D	218 ± 22	180 ± 18	259 ± 26	221 ± 22	880 ± 40
I11E	198 ± 20	191 ± 19	243 ± 24	221 ± 22	850 ± 40
I11F	201 ± 20	204 ± 20	243 ± 24	212 ± 21	860 ± 40
I11G	199 ± 20	182 ± 18	233 ± 23	203 ± 20	820 ± 40
I11H	212 ± 21	214 ± 21	256 ± 26	226 ± 23	910 ± 50
I11I	210 ± 21	197 ± 20	239 ± 24	221 ± 22	870 ± 40
I11J	201 ± 20	192 ± 19	245 ± 25	208 ± 21	850 ± 40
I11K	216 ± 22	195 ± 20	222 ± 22	207 ± 21	840 ± 40
I11L	178 ± 18	177 ± 18	221 ± 22	201 ± 20	780 ± 40
I21A	193 ± 19	187 ± 19	224 ± 22	198 ± 20	800 ± 40
I21B	244 ± 24	219 ± 22	274 ± 27	230 ± 23	970 ± 50
I21C	180 ± 18	187 ± 19	228 ± 23	189 ± 19	780 ± 40
I21D	319 ± 32	308 ± 31	348 ± 35	327 ± 33	1300 ± 70
I21E	255 ± 25	347 ± 35	321 ± 32	275 ± 28	1200 ± 60
I21F	192 ± 19	187 ± 19	240 ± 24	208 ± 21	830 ± 40
I21G	239 ± 24	189 ± 19	249 ± 25	212 ± 21	890 ± 40
I21H	309 ± 31	217 ± 22	257 ± 26	240 ± 24	1020 ± 50
I21I	187 ± 19	183 ± 18	216 ± 22	177 ± 18	760 ± 40
I21J	201 ± 20	188 ± 19	202 ± 20	197 ± 20	790 ± 40
I21K	171 ± 17	182 ± 18	197 ± 20	222 ± 22	770 ± 40
I21L	198 ± 20	191 ± 19	219 ± 22	202 ± 20	810 ± 40

Table 4.06 (continued): Ambient Gamma – TLD (µGy)

Location	Dose (µGy± 10%)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
I75	171 ± 17	174 ± 17	193 ± 19	173 ± 17	710 ± 40
I86	148 ± 15	155 ± 15	181 ± 18	161 ± 16	650 ± 30
I87	136 ± 14	143 ± 14	175 ± 17	148 ± 15	600 ± 30
I88	147 ± 15	150 ± 15	175 ± 18	159 ± 16	630 ± 30
I89	158 ± 16	151 ± 15	173 ± 17	157 ± 16	640 ± 30
J00	144 ± 14	175 ± 18	196 ± 20	174 ± 17	690 ± 30
J20	175 ± 17	158 ± 16	204 ± 20	173 ± 17	710 ± 40
J35	203 ± 20	177 ± 18	203 ± 20	179 ± 18	760 ± 40
J70	293 ± 29	233 ± 23	308 ± 31	301 ± 30	1140 ± 60
K01	134 ± 13	168 ± 17	188 ± 19	162 ± 16	650 ± 30
K02	220 ± 22	184 ± 18	201 ± 20	188 ± 19	790 ± 40
L01	174 ± 17	177 ± 18	174 ± 17	172 ± 17	700 ± 30
L02	182 ± 18	198 ± 20	232 ± 23	294 ± 29	910 ± 50
L03	149 ± 15	142 ± 14	141 ± 14	135 ± 14	570 ± 30
L04	168 ± 17	190 ± 19	168 ± 17	191 ± 19	720 ± 40
M02	NA	257 ± 26	265 ± 27	264 ± 26	1050 ± 50
N01	135 ± 14	151 ± 15	152 ± 15	153 ± 15	590 ± 30
P01	128 ± 13	155 ± 15	178 ± 18	180 ± 18	640 ± 30
P03	127 ± 13	146 ± 15	NA	150 ± 15	560 ± 20
X12	417 ± 42	381 ± 38	391 ± 39	326 ± 33	1520 ± 80
YTL1	146 ± 15	148 ± 15	140 ± 14	131 ± 13	570 ± 30
YTL2	128 ± 13	136 ± 14	133 ± 13	130 ± 13	530 ± 30
YTL3	95 ± 9	117 ± 12	104 ± 10	112 ± 11	430 ± 20
YTL4	94 ± 9	101 ± 10	109 ± 11	107 ± 11	410 ± 20

NA :Data Not Available – Lost or destroyed TLD for this collection interval.

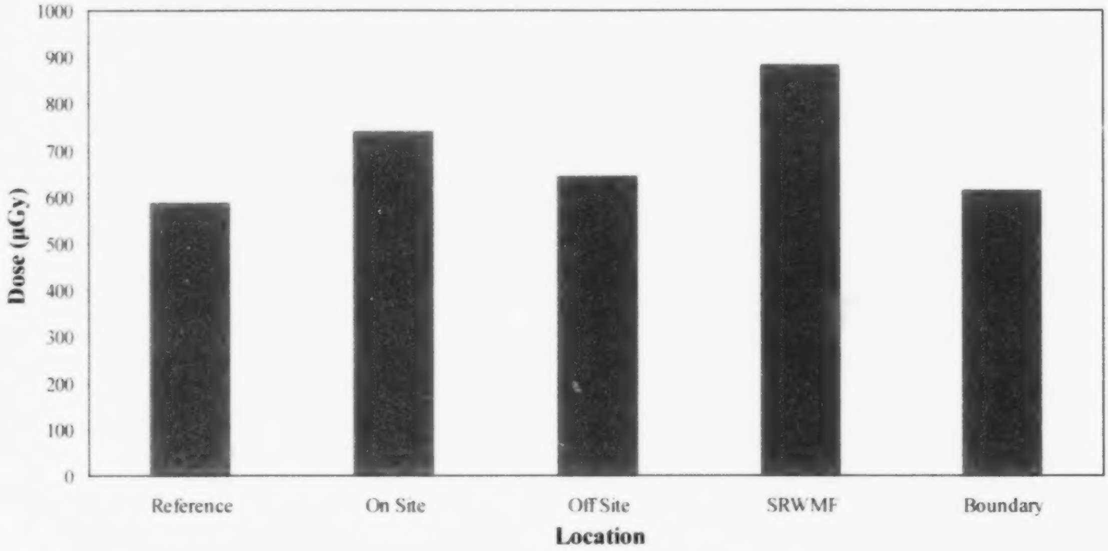


Figure 4.10: Mean Ambient Gamma (TLD) Results

4.06 Milk

Of the 24 samples analysed, K-40 was detected in 24, Cs-137 was detected in one, and H-3 was detected in three. None of these are attributable to the operation of PLGS.

There are no commercial herds or individual cows producing milk in the Point Lepreau area. The closest herds to PLGS are in Oak Bay (60 km to the northwest), Fredericton Junction (70 km to the north), and Hammond River (60 km to the northeast), and the milk from these locations is analysed quarterly. Milk from a commercial dairy is purchased each month from a supermarket in Fredericton. All samples are analysed for gamma emitting radionuclides and tritium.

Since C-14 emissions are low, the expected concentration in milk is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on milk. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions.

Tritium was detected in three of the 24 samples collected (1.6 E+01 $Bq \cdot L^{-1}$ to 1.9 E+01 $Bq \cdot L^{-1}$). This was very near the average Critical Level of 1.1E+01 $Bq \cdot L^{-1}$ and is believed to be statistical "false positives".

Cesium-137 was detected in one sample (8.0E-02 $Bq \cdot L^{-1}$). The Cs-137 originated from fallout of bomb tests and the Chernobyl accident, and concentrations have been declining ever since. Milk samples analysed between 1977 and 1982, before PLGS began operations, contained an average

Cs-137 concentration of 1.2E+00 $Bq{\cdot}L^{-1}$. The cow preferentially absorbs cesium if there is a dietary deficiency in potassium.

Naturally occurring K-40 (average of 5.1E+01 $Bq{\cdot}L^{-1}$) was also detected in milk.

PLGS emissions of tritium and gamma emitters were too low throughout the year to be detected in these milk samples.

Table 4.07 is a summary of the detected radionuclides in milk.

4.07 GEM Particulates (Sr-89,90)

When Sr-89,90 emissions are low, the expected concentration in environmental air samples is below the detection limit. The GEM monitors PLGS gaseous emissions continuously at their source. The GEM filter is changed daily and the weekly composite is sent to the lab for analysis. Fifty-two sets of these GEM filters were analysed for Sr-89,90. If the emission rate is more than 1% DEL, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples. Since no Sr-89 emissions were detected in 2005 and Sr-90 average emissions were 2E-8% DEL (and at no time exceeded 1% DEL), no further analyses were required.

Table 4.07: Milk $(Bq \cdot L^{-1})$

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	24	1.1E+1	1.0E+1 to 1.2E+1	1.7E+1	2/12	1.6E+1 to 1.7E+1	1.9E+1	1/12	1.9E+1 to 1.9E+1
Cs-137	24	4.7E-2	3.6E-2 to 5.3E-2	8.0E-2	1/12	8.0E-2 to 8.0E-2	*	*	*
K-40	24	2.0E+0	1.4E-1 to 3.5E+0	5.0E+1	12/12	4.6E+1 to 5.5E+1	5.1E+1	12/12	4.9E+1 to 5.3E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.07: Milk ($Bq\cdot L^{-1}$)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	24	1.1E+1	1.0E+1 to 1.2E+1	1.7E+1	2/12	1.6E+1 to 1.7E+1	1.9E+1	1/12	1.9E+1 to 1.9E+1
Cs-137	24	4.7E-2	3.6E-2 to 5.3E-2	8.0E-2	1/12	8.0E-2 to 8.0E-2	*	*	*
K-40	24	2.0E+0	1.4E-1 to 3.5E+0	5.0E+1	12/12	4.6E+1 to 5.5E+1	5.1E+1	12/12	4.9E+1 to 5.3E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.08 Well Water

Of the 32 samples analysed, gross alpha was detected in 22, gross beta was detected in 29, and H-3 was detected in 16. Only H-3 is attributable to the operation of PLGS.

Water is collected semi-annually from the 11 locations shown in Figure 3.03. Two of these wells are onsite. Ten additional wells are sampled once per year. These are located just outside the exclusion boundary and belong to local residents.

The alpha (up to 5.7E-01 $Bq{\cdot}L^{-1}$) and beta (up to 3.2E-01 $Bq{\cdot}L^{-1}$) activities are due to the presence of naturally occurring radionuclides peculiar to certain locations. Detected H-3 concentrations ranged from 1.1E+01 to 4.1E+01 $Bq{\cdot}L^{-1}$. Tritium from PLGS emissions washes out into precipitation and subsequently drains into some of the wells. Precipitation analyses (Section 4.14) indicate H-3 concentrations ranging from 1.2E+01 to 7.0E+02 $Bq{\cdot}L^{-1}$ in 37 of 48 samples.

Since C-14 emissions are low, the expected concentration in water is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on water. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions.

Table 4.08 is a summary of the detected radionuclides in well water. Figures 4.11 and 4.12 show the gross beta and H-3 results for each sample. "Less Than" values are plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to reduce radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters.

The 1996 *Guidelines for Canadian Drinking Water Quality*(11) recommends 7.0E+03 $Bq{\cdot}L^{-1}$ as the maximum acceptable average concentration for H-3 in drinking water. The highest well water H-3 content was less than one percent of this value.

Table 4.08: Well Water ($Bq \cdot L^{-1}$)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
Alpha	32	7.6E-2	2.3E-2 to 1.9E-1	1.8E-1	22/32	4.0E-2 to 5.7E-1	*	*	*
Beta	32	4.4E-2	2.2E-2 to 9.9E-2	1.3E-1	29/32	4.6E-2 to 3.2E-1	*	*	*
H-3	32	1.1E+1	9.9E+0 to 1.2E+1	2.1E+1	16/32	1.1E+1 to 4.1E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

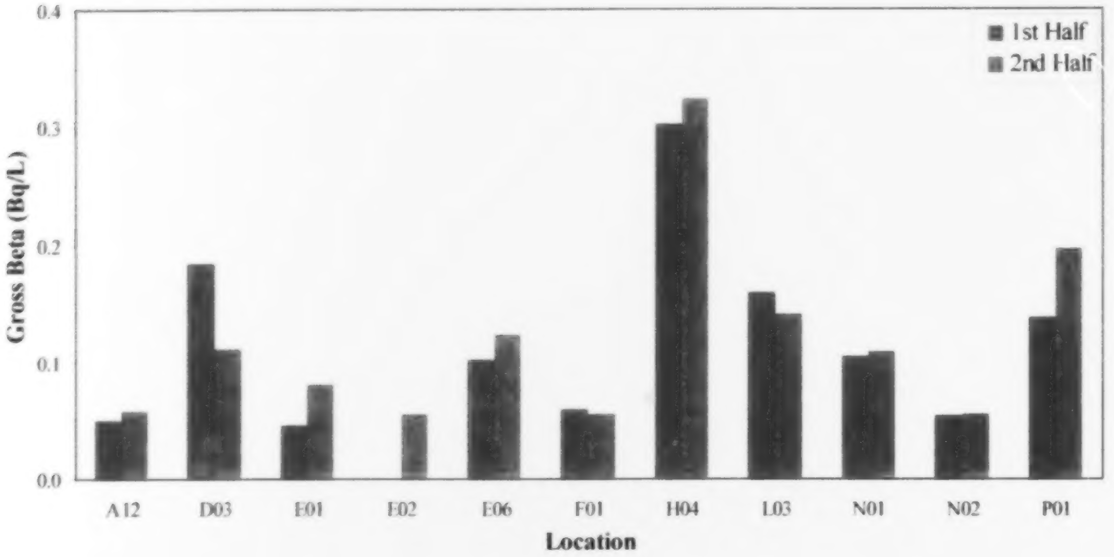


Figure 4.11: Gross Beta (Well Water)

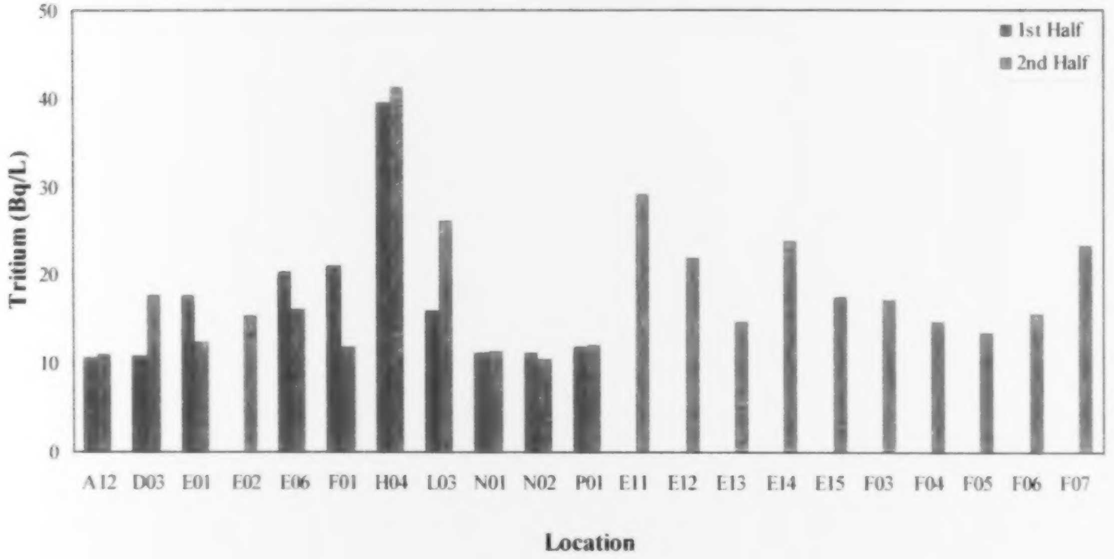


Figure 4.12: Tritium (Well Water)

4.09 Pond/Puddle/Surface Water

Tritium was detected in 12 of the 31 samples. No gamma emitters that are attributable to PLGS emissions were detected.

This category includes ponds, lakes, streams, and runoff samples. Most of these samples are from onsite locations. Two important offsite locations, sampled quarterly, are the freshwater supply reservoirs for Saint John and PLGS, at Spruce Lake and Hanson Stream, respectively.

Detected H-3 activities ranged from 1.3E+01 to 8.5E+01 Bq·L^{-1}. Variability can be due to the size of the reservoir and the residence time at the location. Tritium from PLGS emissions washes out into precipitation. Precipitation analyses (Section 4.14) indicate H-3 concentrations ranging from 1.2E+01 to 7.0E+02 Bq·L^{-1} in 37 of 48 samples.

Since C-14 emissions are low, the expected concentration in water is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on water. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions.

Table 4.09 is a summary of the detected radionuclides in surface water. Figure 4.13 shows H-3 results for each location. "Less Than" values are plotted for non-detected results.

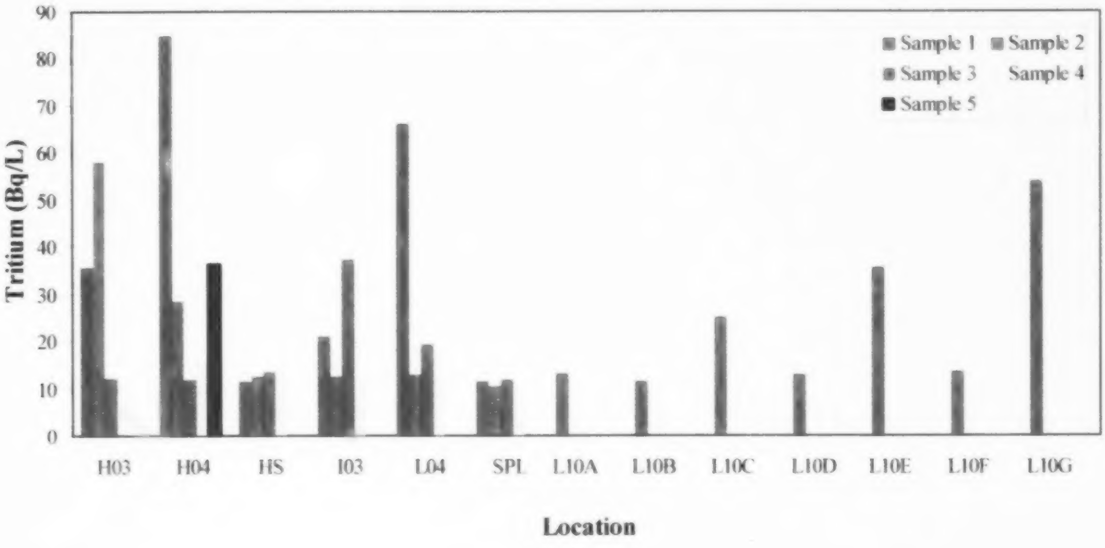


Figure 4.13: Tritium (Pond/Puddle/Surface Water)

Table 4.09: Pond/Puddle/Surface Water (Bq·L^{-1})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	31	1.2E+1	1.1E+1 to 1.4E+1	4.1E+1	12/31	1.3E+1 to 8.5E+1	*	*	*

*There is no reference location.

4.10 Berries

Potassium-40 was detected in one of the five samples analysed. This is not attributable to the operation of PLGS.

Berries are sampled weekly when in season. Four samples of blueberries were from the commercial fields at Pennfield. One sample of cranberries was from Dipper Harbour.

It is not unusual to detect Cs-137 in berries throughout North America (from fallout of past atmospheric bomb tests), although none was seen this year. As in many food samples, naturally occurring K-40 was detected in one sample (3.2E+01 $Bq{\cdot}kg^{-1}$).

Since H-3 and C-14 emissions are low, the expected concentration in berries is below the detection limit. If the H-3 or C-14 emission rates are more than 1% DEL, a H-3 or C-14 analysis is performed on berries. Since the average emission rate in 2005 was 4E-02 %DEL for H-3 and 8E-03 %DEL for C-14 (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.05 shows the weekly H-3 emissions and Figure 4.08 shows the weekly C-14 emissions.

Table 4.10 is a summary of the detected radionuclides in berries.

4.11 Garden Vegetables

Of the 25 samples analysed, K-40 was detected in 22 and Be-7 was detected in one. These are not attributable to the operation of PLGS.

All samples were taken from a local garden in Dipper Harbour (4 km from PLGS in the predominant wind direction). These samples were supplied weekly during the growing season.

As in most food samples, naturally occurring K-40 was detected in 22 samples (5.3E+01 to 2.6E+02 $Bq{\cdot}kg^{-1}$).

Since H-3 and C-14 emissions are low, the expected concentration in garden vegetables is below the detection limit. If the H-3 or C-14 emission rates are more than 1% DEL, a H-3 or C-14 analysis is performed on berries. Since the average emission rate in 2005 was 4E-02 %DEL for H-3 and 8E-03 %DEL for C-14 (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.05 shows the weekly H-3 emissions and Figure 4.08 shows the weekly C-14 emissions.

Table 4.11 is a summary of the detected radionuclides in garden vegetables.

4.12 Vegetation (Lichen)

Of the 15 samples analysed, Be-7 was detected in 15, Cs-137 in one and K-40 in three. None of these are attributable to the operation of PLGS.

These samples are collected whenever and wherever available from onsite locations.

Different species of lichen and moss concentrate a wide range of radionuclides and are sensitive indicators of radionuclides in the environment. Cosmogenically produced Be-7 was detected in 15 samples (2.0E+02 to 5.9E+02 $Bq{\cdot}kg^{-1}$), Cs-137 was detected in one sample (1.5E+01 $Bq{\cdot}kg^{-1}$)and naturally occurring K-40 was detected in three samples (8.5E+01 to 1.3E+02 $Bq{\cdot}kg^{-1}$). It is not unusual to detect Cs-137 in lichen throughout North America. In past years, lichen from a now abandoned reference location contained Cs-137 concentrations up to 3.2E+02 $Bq{\cdot}kg^{-1}$ (average 6.5E+01 $Bq{\cdot}kg^{-1}$).

Table 4.12 is a summary of the detected radionuclides in vegetation.

Table 4.10: Berries, Various (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	5	3.0E+1	2.6E+1 to 4.2E+1	3.2E+1	1/5	3.2E+1 to 3.2E+1	*	*	*

*There is no reference location.

Table 4.11: Garden Vegetables (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	25	1.6E+1	7.0E+0 to 3.8E+1	4.9E+1	1/25	4.9E+1 to 4.9E+1			
K-40	25	5.3E+1	4.9E+0 to 1.6E+2	1.3E+2	22/25	5.3E+1 to 2.6E+2	*	*	*

*There is no reference location.

Table 4.12: Vegetation (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	15	5.3E+1	1.9E+1 to 2.0E+2	3.5E+2	15/15	2.0E+2 to 5.9E+2	*	*	*
Cs-137	15	9.8E+0	4.4E+0 to 1.5E+1	1.5E+1	1/15	1.5E+1 to 1.5E+1			
K-40	15	1.5E+2	4.1E+1 to 2.4E+2	1.1E+2	3/15	8.5E+1 to 1.3E+2	*	*	*

*There is no reference location.

4.13 Soil

Of the 36 samples analysed, Be-7 was detected in 11, Cs-137 in 18, Ac-228 was detected in 25, and K-40 in 32. None of these are attributable to the operation of PLGS.

Soil samples are taken quarterly from the eight air monitoring location sites shown in Figure 3.02 and from the local elementary school. Samples are collected at E02 rather than E01 due to a lack of readily available soil at this site.

Most samples contained naturally occurring K-40 (1.0E+02 to 9.7E+02 Bq·kg^{-1}) and Ac-228 (2.5E+01 to 1.0E+02 Bq·kg^{-1}), and cosmogenically produced Be-7 (1.1E+01 to 1.1E+02 Bq·kg^{-1}). Eighteen contained Cs-137 (3.1E+00 to 1.4E+02 Bq·kg^{-1}) at typical levels for the region (see Table 4.13). Cesium-137 from fallout of past atmospheric bomb tests tends to accumulate in the organic layer of the soil. Any fluctuation in Cs-137 levels seems to be due to this organic load in the sample.

Table 4.13 is a summary of the detected radionuclides in soil. Figure 4.14 shows individual Cs-137. "Less Than" values are plotted for non-detected results.

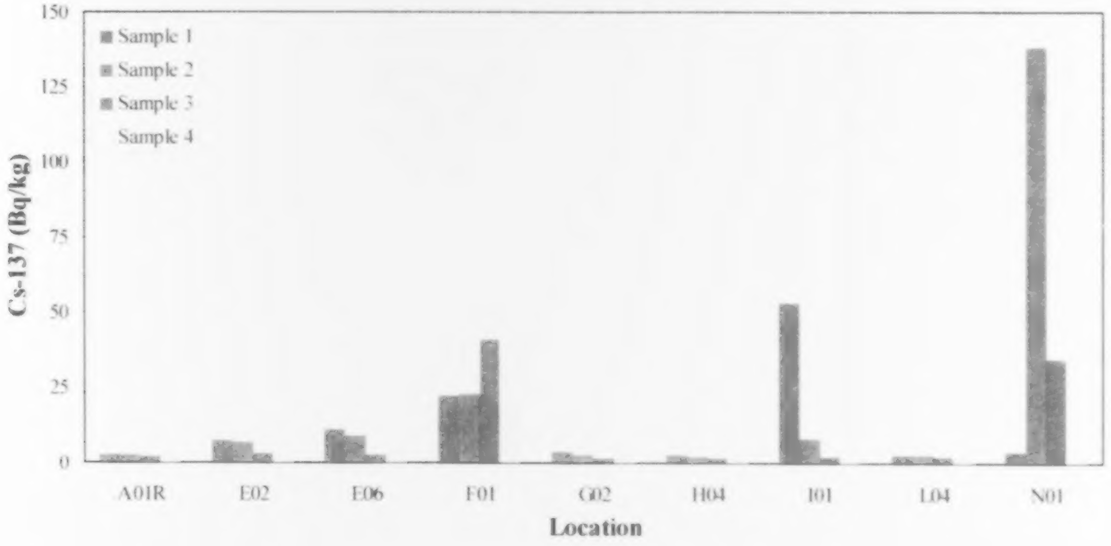


Figure 4.14: Cesium-137 (Soil)

Table 4.13: Soil (Bq·kg^{-1})

Analysis Type	Total Number	Critical Level		Indicator Locations			Reference Locations		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	36	1.4E+1	6.4E+0 to 5.2E+1	4.8E+1	11/32	1.1E+1 to 1.1E+2	1.8E+1	1/4	1.8E+1 to 1.8E+1
Cs-137	36	2.4E+0	6.2E-1 to 2.0E+1	3.0E+1	18/32	3.1E+0 to 1.4E+2	*	*	*
Ac-228	36	4.9E+0	1.6E+0 to 2.0E+1	4.3E+1	25/32	2.5E+1 to 7.4E+1	6.4E+1	4/4	4.3E+1 to 1.0E+2
K-40	36	8.7E+1	4.5E+0 to 1.4E+2	6.0E+2	32/32	1.0E+2 to 9.7E+2	7.5E+2	4/4	6.5E+2 to 8.8E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.14 Precipitation

Of the 48 samples analysed, H-3 was detected in 37 and Be-7 in two. The H-3 is attributable to the operation of PLGS.

Precipitation is collected continuously at the four onsite air monitoring stations (locations shown in Figure 3.02). The samples are changed approximately monthly, depending on rainfall and freeze up.

Detected H-3 levels spanned 2.4E+01 to 3.2E+02 Bq·L^{-1}, depending on the amount of rainfall. Cosmogenically produced Be-7 was detected in two samples (2.9E+00 to 4.3E+00 Bq·L^{-1})

Since C-14 emissions are low, the expected concentration in water is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on water. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions.

Table 4.14 is a summary of the detected radionuclides in precipitation. Figure 4.15 shows individual H-3 results. "Less Than" values are plotted for non-detected results.

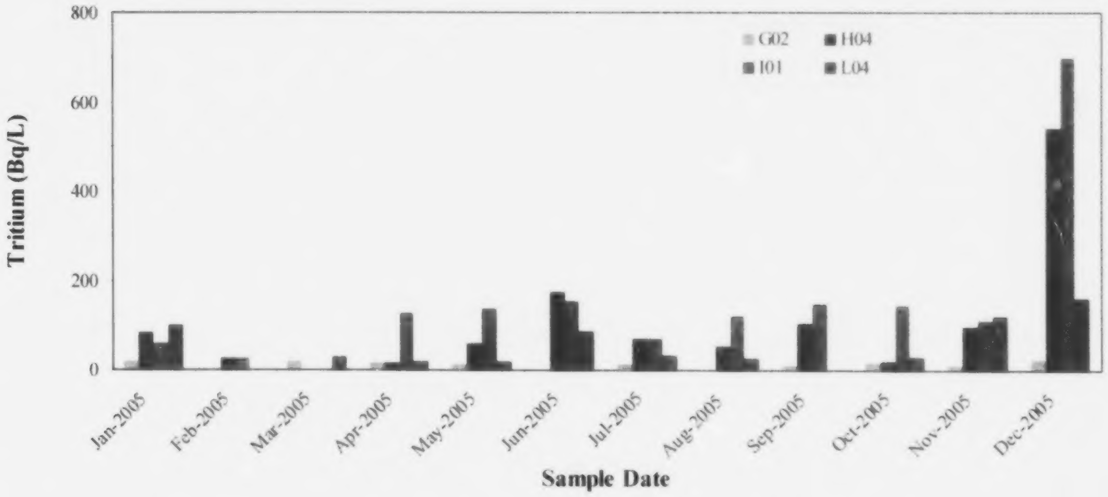


Figure 4.15: Tritium (Precipitation)

Table 4.14: Precipitation (Bq·L^{-1})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	48	1.1E+1	1.0E+1 to 1.2E+1	1.0E+2	37/48	1.2E+1 to 7.0E+2	*	*	*
Be-7	48	2.5E+0	1.2E+0 to 5.5E+0	3.6E+0	2/48	2.9E+0 to 4.3E+0	*	*	*

*There is no reference location.

4.15 Monitoring Well Water, Near Plant

Of the 24 samples analysed, H-3 was detected in 21, Ac-228 in one and K-40 in two. Only H-3 is attributable to PLGS emissions.

These wells are sampled once per year. This frequency may be increased for some or all wells if H-3 concentrations greater than 7000 Bq·L^{-1} are detected, or if an abnormal release is suspected. An additional 13 wells were drilled and sampled in 2005. These are part of the landfill closure assessment of the Fire Fighting Training Area.

Tritium concentrations averaged 1.0E+02 Bq·L^{-1}, ranging up to 3.0E+02 Bq·L^{-1}. The highest concentrations are found close to the stack at locations J02A and J02B. Tritium from PLGS emissions washes out into precipitation and subsequently drains into some of the wells. Precipitation analyses (Section 4.14) indicate H-3 concentrations ranging from 1.2E+01 to 7.0E+02 Bq·L^{-1} in 37 of 48 samples.

Since C-14 emissions are low, the expected concentration in water is below the detection limit. If the C-14 emission rate is more than 1% DEL, a C-14 analysis is performed on water. Since the average emission rate in 2005 was 8E-03% DEL (and at no time exceeded 1% DEL), no further analyses were required. Figure 4.08 shows the weekly C-14 emissions.

Table 4.15 is a summary of the detected radionuclides in monitoring well water. Figure 4.16 shows individual H-3 results. "Less Than" values are plotted for non-detected results.

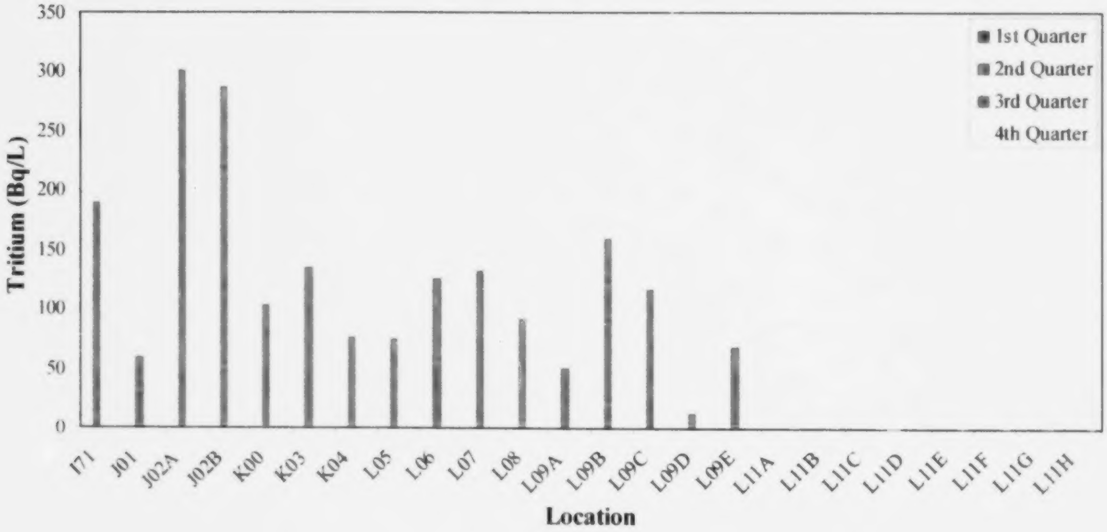


Figure 4.16: Tritium (Monitoring Well Water, Near Plant)

Table 4.15: Monitoring Well Water, Near Plant (Bq·L^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	24	1.2E+1	1.1E+1 to 1.3E+1	1.0E+2	21/24	1.7E+1 to 3.0E+2	*	*	*
Ac-228	24	1.3E+0	4.8E-1 to 3.4E+0	4.8E+0	1/24	4.8E+0 to 4.8E+0	*	*	*
K-40	24	6.4E+0	2.1E+0 to 2.4E+1	4.1E+1	2/24	3.4E+1 to 4.7E+1	*	*	*

*There is no reference location.

4.16 Seawater

Of the 16 samples analysed, K-40 was detected in 16 and H-3 was detected in four. The H-3 is attributable to the operation of PLGS.

Seawater is collected quarterly from three locations close to PLGS and one reference location near Saint John (shown in Figure 3.05).

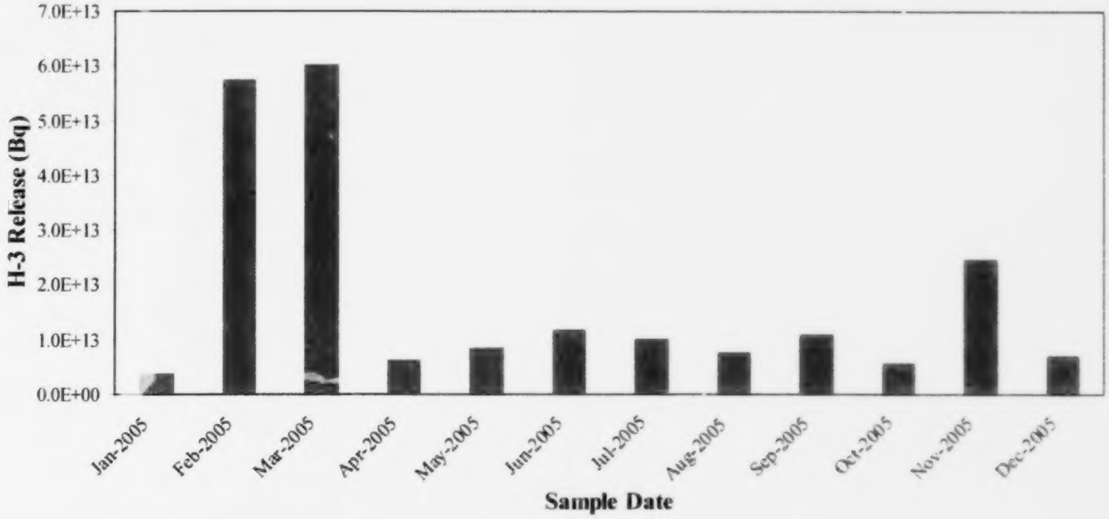
Naturally occurring K-40 was detected (7.3E+00 to 1.5E+01 $Bq \cdot L^{-1}$) in all 16 samples. Tritium was detected in four samples (1.4E+01 and 2.9E+01). Calculations suggest that the long term average concentration of tritium in seawater, due to emissions from PLGS in the liquid pathway, would be about 1.4E+01 $Bq \cdot L^{-1}$ at the out-fall (samples are not usually collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 24 $m^3 \cdot s^{-1}$), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away, a tidal mixing factor of about 40, or even higher, is more realistic. A factor of 40 would result in an average H-3 concentration of about 7.0E+00 $Bq \cdot L^{-1}$ of seawater in 2005 at the H03 location.

When C-14 and Sr-89,90 emissions are low, the expected concentration in seawater is below the detection limit. If the emission rate is more than 1% DEL, a C-14 or Sr-89,90 analysis is performed on seawater. Since the average emission rate in 2005 was 7E-04 %DEL for C-14 and 1E-04 %DEL for Sr-90 (and at no time exceeded 1% DEL), no further analyses were required. Sr-89 was not detected in releases Figure 4.18 shows the monthly C-14 emissions and Figure 4.20 shows the Sr-90 emissions.

Table 4.16 is a summary of the detected radionuclides in seawater.

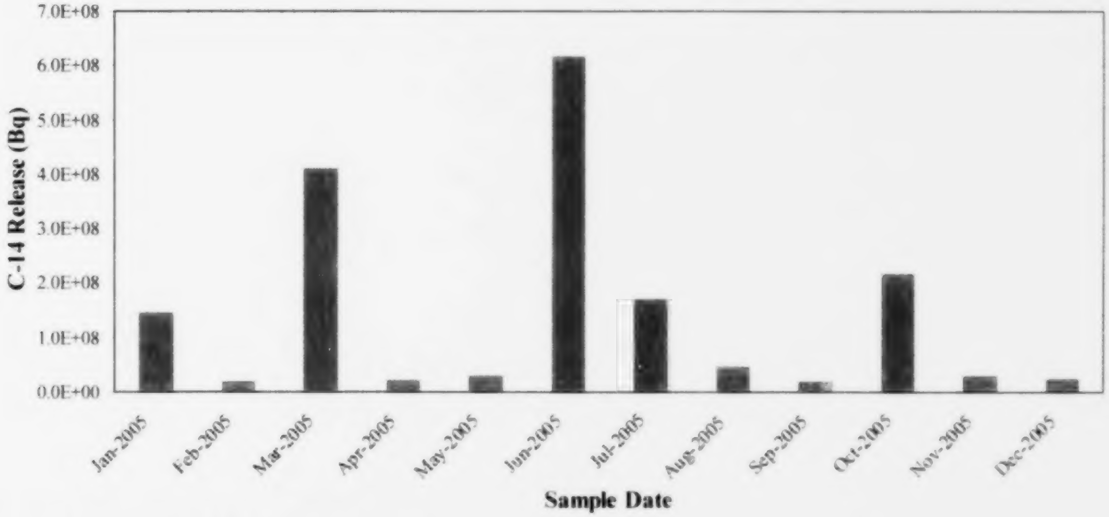
4.17 Tritium and C-14 Analyses of Seafood

When H-3 and C-14 emissions are low, the expected concentrations in seafood are below the detection limit. If the emission rate is more than 1% DEL, a H-3 or C-14 analysis is performed on seafood. Since the average emission rate in 2005 was 2E-03 %DEL for H-3 and 7E-4 %DEL for C-14 (and at no time exceeded 1% DEL), no further analyses were required. Figures 4.17 and 4.18 shows the monthly emissions of these radionuclides.



Note: The DEL for H-3 is 1.6E+19 Bq·a^{-1}

Figure 4.17: Liquid H-3 Emissions



Note: The DEL for C-14 is 3.0E+14 Bq·a^{-1}

Figure 4.18: Liquid C-14 Emissions

Table 4.16: Seawater (Bq·L^{-1})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	16	1.2E+1	1.1E+1 to 1.4E+1	2.0E+1	4/12	1.4E+1 to 2.9E+1	*	*	*
K-40	16	2.9E+0	7.6E-1 to 5.9E+0	1.1E+1	12/12	7.3E+0 to 1.5E+1	8.5E+0	4/4	3.8E+0 to 1.1E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.18 Seafood

Potassium-40 is usually detected in these samples. This is not attributable to the operation of PLGS. Figure 3.05 shows the locations for most of these samples.

Clams – Seven samples were collected from the area. The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination or algal blooms. This restricts the availability of these sample types for analysis. Data are shown in Table 4.17.

Fish - No fish samples were available for analysis in 2005. The fish category now tends to be made up of dogfish, cod, hake and sardines, if they are available at all.

Lobster - All of the six samples were collected close to the cooling water outflow from PLGS. A few lobster are obtained during each of the two federally regulated fishing seasons per year. Data are shown in Table 4.18.

Periwinkles – Nine of the ten samples were collected in Dipper Harbour. Data are shown in Table 4.19.

Aquaculture Salmon - The aquaculture salmon industry is important to the area west of PLGS. Late in 2004, a new facility close to the PLGS outfall in Duck Cove began operation. Three of the four samples were from this location. Data are shown in Table 4.20.

Scallops - The inshore fishery often faces restrictions or total bans placed upon the harvesting of scallops for the conservation of stocks. When available, samples are obtained from Maces Bay or areas distant from the plant. No samples were collected in 2005.

Crab - As in most years, there was no active crab fishery in the local area. No samples were available for analysis in 2005.

Dulse - Dulse is an edible seaweed that is a popular snack food in the area. Twelve samples were collected in 2005. Data are shown in Table 4.21.

4.19 Other Sea Plants

Of the 12 samples analysed, Be-7 was detected in two and K-40 in 12. These are not attributable to the operation of PLGS.

Sea plants other than dulse are analysed. Various species of seaweed (for example, *Ascophylum*) occur on the rocks on the Point Lepreau peninsula and are collected from time to time. Sample locations are shown in Figure 3.05. Data are shown in Table 4.21.

The cosmogenically produced Be-7 concentration were 9.0E+00 and 1.2E+01Bq·kg^{-1}. Naturally occurring K-40 ranged from 1.5E+02 to 2.9E+02 Bq·kg^{-1}. See Table 4.22.

Table 4.17: Clams, Edible, Raw Mass ($Bq \cdot kg^{-1}$)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	7	8.7E+1	2.6E+1 to 2.0E+2	2.3E+2	7/7	1.1E+2 to 4.1E+2	*	*	*

Table 4.18: Lobster, Edible, Cooked Mass (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	6	5.7E+1	4.9E+1 to 7.2E+1	8.0E+1	3/6	7.3E+1 to 8.7E+1	*	*	*

*There is no reference location.

Table 4.19: Periwinkles, Edible, Raw Mass (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	10	3.4E+1	1.6E+1 to 9.1E+1	1.3E+2	9/10	7.7E+1 to 3.1E+2	*	*	*

*There is no reference location.

Table 4.20: Aquaculture Salmon, Raw Mass (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	4	2.4E+1	1.9E+1 to 2.9E+1	1.2E+2	4/4	1.1E+2 to 1.4E+2	*	*	*

*There is no reference location.

Table 4.21: Dulse, Wet Mass (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	12	9.2E+1	9.5E+0 to 1.7E+2	4.7E+2	12/12	3.0E+2 to 8.2E+2	*	*	*

*There is no reference location.

Table 4.22: Sea Plants, Wet Mass (Bq·kg⁻¹)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
Be-7	12	4.9E+0	1.8E+0 to 6.8E+0	1.1E+1	2/12	9.0E+0 to 1.2E+1	*	*	*
K-40	12	4.2E+1	2.8E+1 to 5.6E+1	2.1E+2	12/12	1.5E+2 to 2.9E+2	*	*	*

*There is no reference location.

4.20 Sediment

Of the 40 samples analysed, Be-7 was detected in 16, Cs-137 in three, Ac-228 in 28, and K-40 in 40. None of these are attributable to the operation of PLGS.

Sediments are collected quarterly from ten locations shown in Figure 3.05. The finer grains are analysed.

All samples contained K-40 (4.1E+02 to 6.8E+02 Bq·kg^{-1}) from the natural potassium in feldspar, a common mineral. Sixteen samples contained cosmogenically produced Be-7 (1.3E+01 to 6.5E+01 Bq·kg^{-1}). Twenty-eight samples contained Ac-228 (1.2E+01 to 5.8E+01 Bq·kg^{-1}), a radioactive progeny of naturally occurring Th-232. Three contained Cs-137 (2.0E+00 to 3.4E+00 Bq·kg^{-1}) from the diminishing levels of Cs-137 fallout from bomb tests since the 1960s. Sediment samples analysed between 1977 and 1982, before PLGS began operations, contained an average Cs-137 concentration of 5.0E+00 Bq·kg^{-1}. A small additional Cs-137 component from Chernobyl was added to this reservoir in 1986. Finer grain sediments have a higher radioactivity content than coarse sediments.

Table 4.23 is a summary of the detected radionuclides in sediment. Figure 4.19 shows individual Cs-137 results. "Less Than" values are plotted for non-detected results.

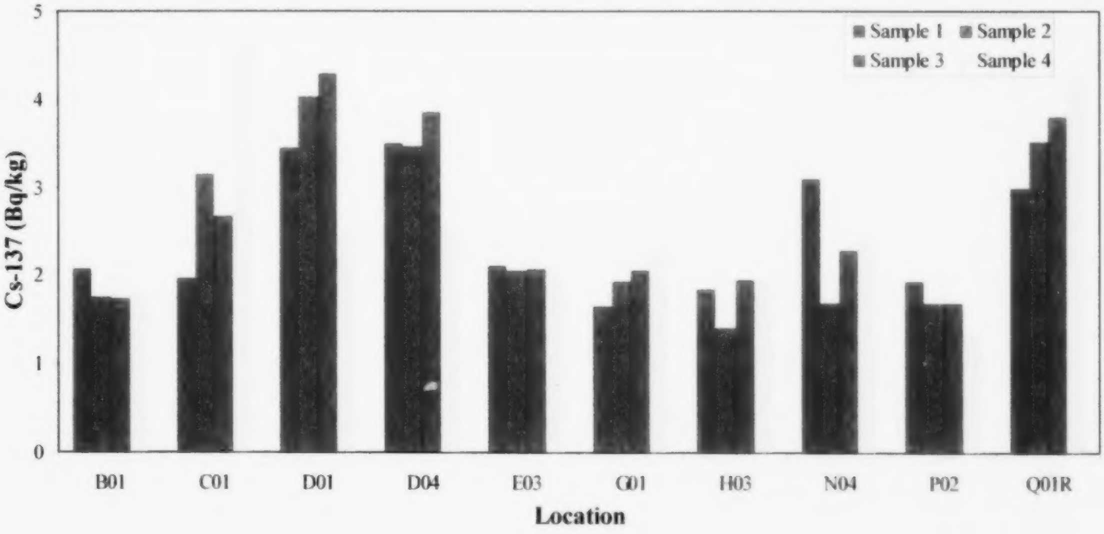


Figure 4.19: Cesium-137 (Sediment)

Table 4.23: Sediment (Bq·kg^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	40	8.5E+0	5.0E+0 to 1.7E+1	2.8E+1	12/36	1.5E+1 to 6.5E+1	3.6E+1	4/4	1.3E+1 to 4.6E+1
Cs-137	40	1.2E+0	6.8E-1 to 2.4E+0	2.6E+0	3/36	2.0E+0 to 3.4E+0	*	*	*
Ac-228	40	3.1E+0	1.9E+0 to 6.6E+0	2.4E+1	25/36	1.2E+1 to 5.8E+1	4.1E+1	3/4	3.1E+1 to 4.7E+1
K-40	40	7.3E+1	2.4E+0 to 1.2E+2	5.5E+2	36/36	4.1E+2 to 6.8E+2	5.6E+2	4/4	4.9E+2 to 6.0E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.21 Ambient Gamma Measurements of Intertidal Zone (Ion Chamber)

Environmental gamma survey measurements are made in the intertidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east-northeast (Figure 3.05). Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Instead, beach surveys are performed and grab samples of sediments are analysed. Radiation values measured in 2005 were consistent with those measured prior to station start-up in 1982. These are summarised in Table 4.24.

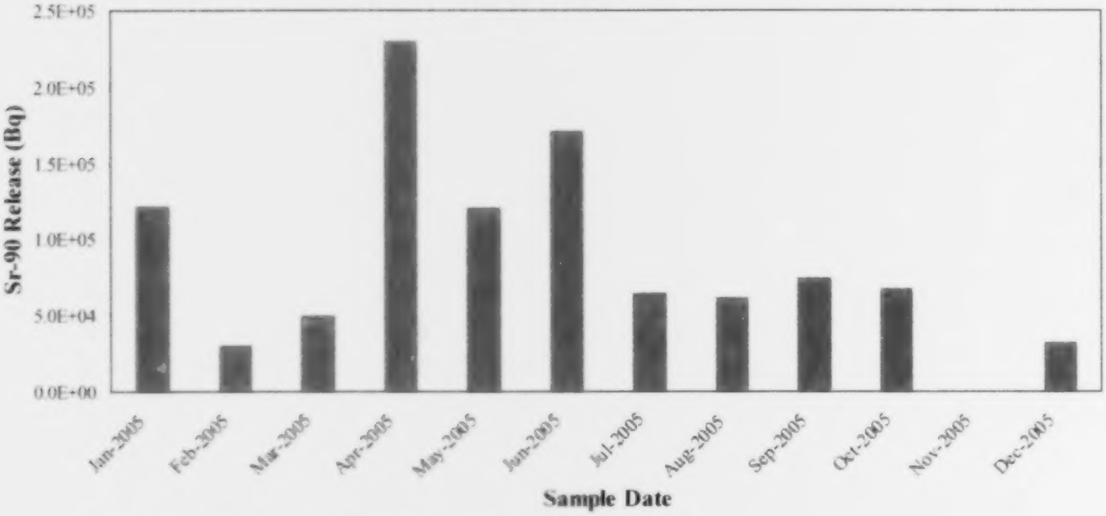
Table 4.24: Ambient Gamma Measurements of Intertidal Zone (Ion Chamber) –(μSv·h^{-1})

Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
B01	0.11	0.12	0.11	0.14
C01	0.10	0.13	0.11	0.12
D01	0.11	0.11	0.10	0.10
D04	0.11	0.10	0.08	0.11
E03	0.12	0.14	0.11	0.12
G01	0.22	0.14	0.15	0.15
H03	0.14	0.11	0.11	0.12
N04	0.11	0.13	0.13	0.12
P02	0.13	0.09	0.11	0.11
Q01R	0.10	0.13	0.10	0.08

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated from the low level gamma meter at each location. They should be regarded as about 0.1 to 0.2 μSv·h^{-1}.

4.22 LEM Composite Water (Sr-89,90)

When Sr-89,90 emissions are low, the expected concentration in seawater is below the detection limit. The LEM collects samples of PLGS liquid emissions at their source. A monthly composite is sent to the lab for analyses. Thirteen of these composites were analysed for Sr-89,90. If the emission rate is more than 1% DEL, a Sr-89,90 analysis is performed on seawater. Since the average emission rate in 2005 was 1E-07 %DEL (and at no time exceeded 1%DEL) for Sr-90 and Sr-89 was not detected, no further analyses were required. Figure 4.20 shows the Sr-90 emissions.



Note: The DEL for Sr-90 is 2.2E+15 Bq a^{-1}

Figure 4.20: Liquid Sr-90 Emissions

4.23 Bore Hole Water, SRWMF

Of the 68 samples analysed, H-3 was detected in 62 and Ac-228 in one. Only the H-3 is attributable to the operation of PLGS.

Groundwater movement near the SRWMF was characterized in 2003. Based on the report by a hydrogeologist, improvements were made to the program. Samples are taken three times per year from 24 drilled wells. Occasionally, a well is dry and no sample is available.

Tritium concentrations averaged 1.2E+02 Bq·L^{-1} (1.7E+01 to 3.3E+02 Bq·L^{-1}) near the Phase 1 facility and 5.0E+01 Bq·L^{-1} (1.1E+01 to 3.0E+02 Bq·L^{-1}) near the Phase 2 facility. Tritium washes out into precipitation and subsequently drains into some of the bore holes. Precipitation analyses indicate H-3 concentrations ranging from 1.2E+01 to 7.0E+02 Bq·L^{-1} in 37 of 48 samples (Section 4.14). See Tables 4.25 and 4.26. Figure 4.21 shows the H-3 activity at each bore hole for each sample. Locations I10A-I10F are the closest to the SRWMF- Phase 1 structures and may be affected by the higher H-3 levels associated with them. "Less Than" values are plotted for non-detected results.

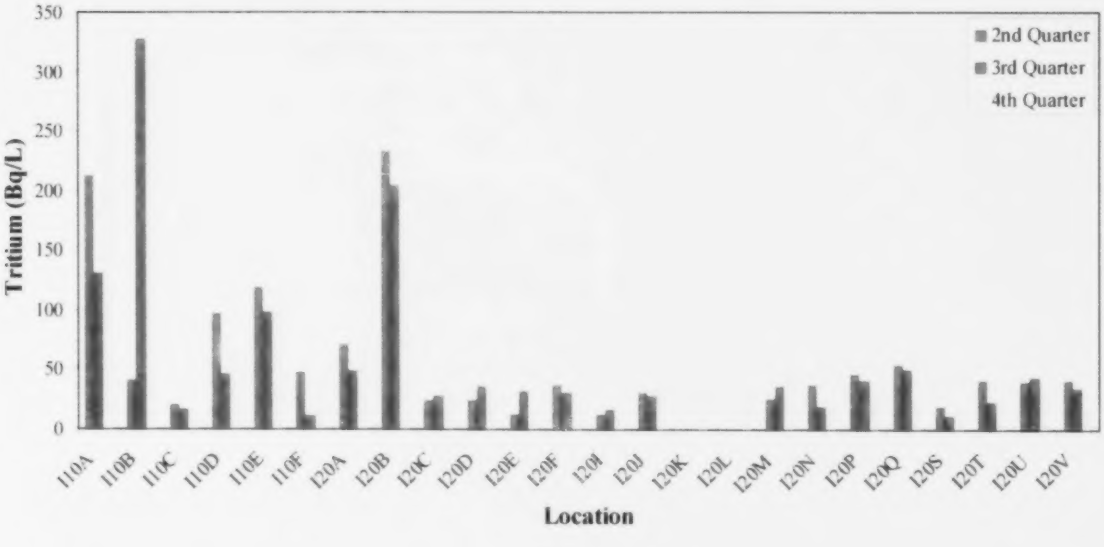


Figure 4.21: Tritium (Bore Hole Water, SRWMF)

Table 4.25: Bore Hole Water, SRWMF - Phase 1 (Bq·L^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	18	1.1E+1	1.1E+1 to 1.3E+1	1.2E+2	16/18	1.7E+1 to 3.3E+2	*	*	*

*There is no reference location.

Table 4.26: Bore Hole Water, SRWMF - Phase 2 (Bq·L^{-1})

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	50	1.1E+1	1.0E+1 to 1.7E+1	5.0E+1	46/50	1.1E+1 to 3.0E+2	*	*	*
Ac-228	48	7.5E-1	4.8E-1 to 1.5E+0	2.8E+0	1/48	2.8E+0 to 2.8E+0	*	*	*

*There is no reference location.

4.24 Parshall Flume Water, SRWMF

Of the 104 samples analysed, H-3 was detected in 97. This is attributable to the emissions from PLGS and the material stored in the Phase 1 structures.

Rainwater and snow melt at the SRWMF (Phases 1 and 2) are obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analysed on a weekly basis.

There is little or no flow into or out of these collection locations during the winter months and values for H-3 tend to vary little from one week to the next except after heavy rain. The average value at Phase 2 is 4.8E+01 $Bq \cdot L^{-1}$, much less than the 1.3E+03 $Bq \cdot L^{-1}$ at Phase 1. The Phase 1 results are due to H-3 vapour escaping from the structures and condensing onto surfaces. Tables 4.27 and 4.28 are summaries of the detected radionuclides in the flumes. Figure 4.22 compares the H-3 in the samples from the two facilities. "Less Than" values are plotted for non-detected results.

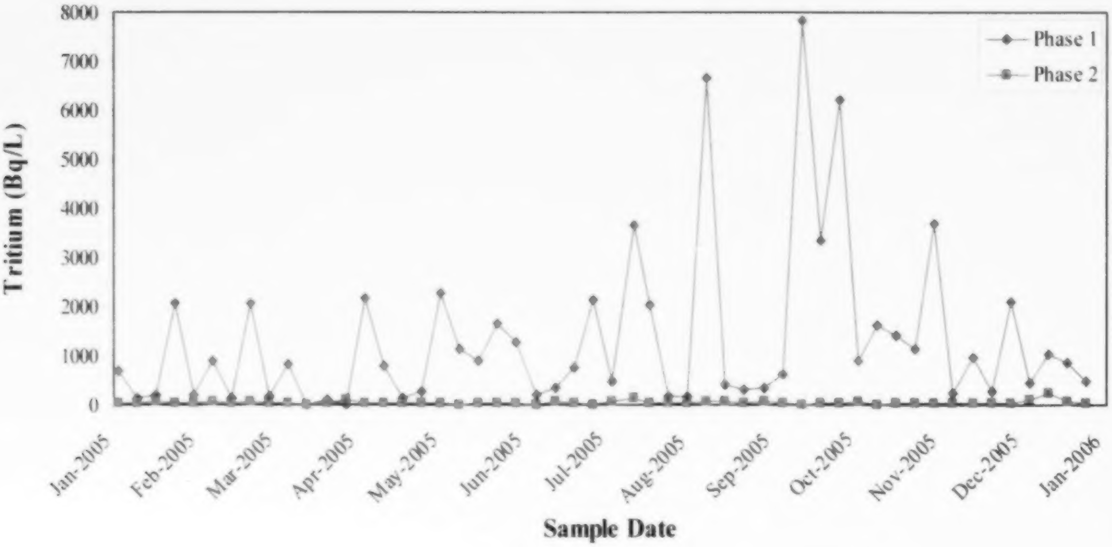


Figure 4.22: Tritium (Parshall Flume Water, SRWMF)

Table 4.27: Parshall Flume Water, SRWMF - Phase 1 ($Bq{\cdot}L^{-1}$)

Analysis Type	***Total Number***	***Critical Level***		***Indicator Locations***			***Reference Locations***		
		Mean	***Range***	***Mean***	***Frequency***	***Range***	***Mean***	***Frequency***	***Range***
H-3	52	1.1E+1	1.0E+1 to 1.4E+1	1.3E+3	52/52	1.6E+1 to 7.8E+3	*	*	*

*There is no reference location.

Table 4.28: Parshall Flume Water, SRWMF - Phase 2 (Bq·L^{-1})

Analysis Type	*Total Number*	*Critical Level*		*Indicator Locations*			*Reference Locations*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	52	1.1E+1	1.0E+1 to 1.2E+1	4.8E+1	45/52	1.3E+1 to 2.3E+2	*	*	*

*There is no reference location.

4.25 Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

The measured radiation decreases as the distance from the SRWMF - Phase 2 increases.

Ambient gamma radiation is measured by TLDs placed at 13 locations in two directions from the boundary fence of Phase 2. These measure decreasing levels of radiation with distance from the filled dry fuel storage canisters, to a distance of about 25 metres. TLDs are changed quarterly. Results are presented in Table 4.29.

There were 129 concrete canisters filled to the end of 2005 with 69,660 used-fuel bundles. Radiation "drop-off" measurements (Figure 4.23) with increasing distance from the fence show distinct differences. The "A" direction consists mostly of swamp after 20 m from the fence and extends to the northeast away from the perimeter fence. The "B" direction consists mostly of rock with some shallow sandy overburden and extends to the northwest away from the perimeter (after 75 m the TLDs are shielded from the facility by high ground). The "B" TLDs are closer to freshly filled canisters than "A" TLDs.

The TLD locations furthest from the facility in the "A" direction (A6 to A9) were discontinued at the end of 2004. They are hazardous for personnel to access and provided limited useful information.

Table 4.29: Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2 (µGy)

	Dose (µGy ± 10%)				
Location	***1st Quarter***	***2nd Quarter***	***3rd Quarter***	***4th Quarter***	***Year***
A 5m	254 ± 25	285 ± 29	219 ± 22	248 ± 25	1010 ± 50
A 10m	222 ± 22	268 ± 27	216 ± 22	231 ± 23	940 ± 50
A 15m	215 ± 22	205 ± 20	186 ± 19	206 ± 21	810 ± 40
A 20m	118 ± 12	147 ± 15	140 ± 14	136 ± 14	540 ± 30
A 25m	125 ± 13	133 ± 13	119 ± 12	122 ± 12	500 ± 20
B 5m	275 ± 27	333 ± 33	274 ± 27	271 ± 27	1150 ± 60
B 10m	266 ± 27	321 ± 32	261 ± 26	261 ± 26	1110 ± 60
B 15m	243 ± 24	306 ± 31	243 ± 24	276 ± 28	1070 ± 50
B 20m	166 ± 17	208 ± 21	199 ± 20	168 ± 17	740 ± 40
B 25m	187 ± 19	225 ± 22	185 ± 19	191 ± 19	790 ± 40
B 50m	162 ± 16	192 ± 19	164 ± 16	177 ± 18	690 ± 30
B 75m	151 ± 15	169 ± 17	161 ± 16	164 ± 16	650 ± 30
B 100m	182 ± 18	204 ± 20	182 ± 18	186 ± 19	750 ± 40

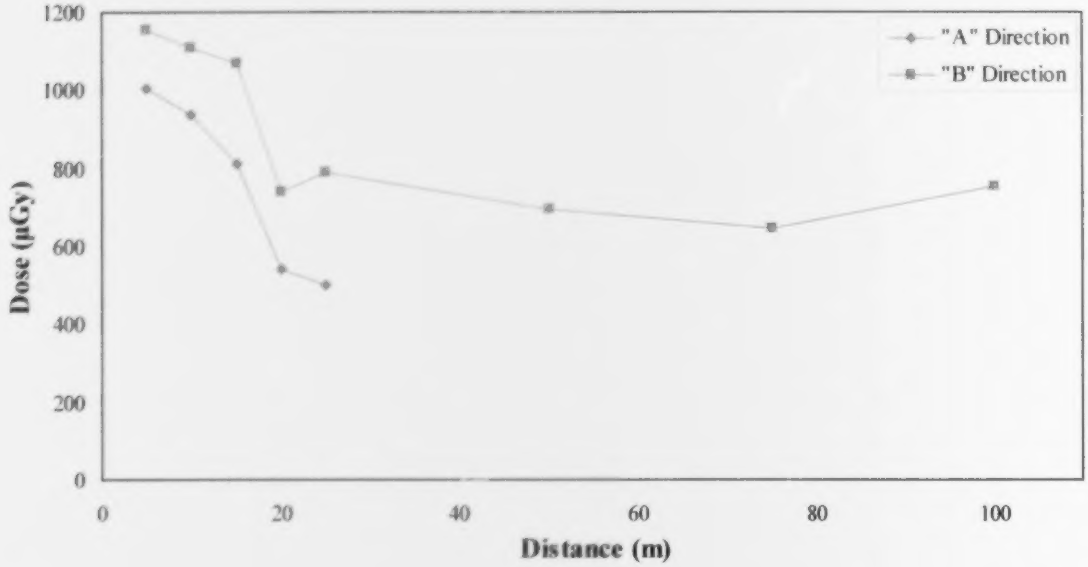


Figure 4.23: Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

4.26 Hemlock Knoll Regional Sanitary Landfill Program

PLGS disposes of its non-active waste at the public landfill facility. The monitoring program includes sampling of water from the leachate, monitoring wells and various holding ponds, and dosimeter placement at key locations.

There were 54 water samples and 16 TLD results. Tritium was detected in 12 of the 50 water samples (mean of 3.7E+02 $Bq{\cdot}L^{-1}$). Table 4.30 summarises the water sample results. There were no radionuclides detected other than naturally occurring isotopes that are not reported here. TLD results appear in Table 4.06 (location codes YTL1 to YTL4).

In 2005, the leachate from Crane Mountain Regional Sanitary Landfill was analysed and found to have H-3 levels similar to those at Hemlock Knoll. PLGS does not ship waste to that facility. The source of H-3 in both of these landfills is suspected to be H-3 in commercial and consumer devices (e.g., H-3 powered "Exit" signs). This is a common occurance throughout North America.

Table 4.30: Water, Hemlock Knoll Regional Sanitary Landfill (Bq·L^{-1})

Analysis Type	Total Number	Critical Level		Indicator Locations			Reference Locations		
		Mean	**Range**	**Mean**	**Frequency**	**Range**	**Mean**	**Frequency**	**Range**
H-3	54	5.9E+1	5.4E+1 to 6.8E+1	3.7E+2	12/54	7.2E+1 to 7.5E+2	*	*	*

*There is no reference location.

4.27 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42-metre elevation (at the Point Lepreau Generating Station tower) contained a bias that affected the calculation of the Pasquill Stability factor. This does not affect the program. The compilation of the available 1986 to 2003 data have this information removed and are presented in Table 4.32. The meteorological data for 2005 were collected at ten minutes intervals and are presented in Table 4.31. Wind Rose data for 2005 are presented in Figure 4.24, and a pie-plot of the average percent frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.25.

Table 4.31: Meteorological Data for Point Lepreau (2005)

	Temperature (Degrees Celsius) 10 Metre Tower Data					*Wind Direction* (Relative %) 42 Metre Tower Data*							
		Mean Daily		*Extreme*		*%Observations from*							
Month	***Avg***	***Max***	***Min***	***Max***	***Min***	***N***	***NE***	***E***	***SE***	***S***	***SW***	***W***	***NW***
January	-8.1	-3.6	-12.5	10.6	-24.0	30	15	9	9	9	8	9	11
February	-3.7	0.1	-8.0	7.1	-19.2	26	11	7	6	7	15	14	14
March	-0.5	3.7	-4.2	10.8	-13.8	22	12	6	7	7	8	14	26
April	4.5	8.4	1.4	18.8	-2.1	24	16	8	12	9	9	10	12
May	7.6	11.1	5.0	14.5	-0.6	27	16	6	11	7	7	11	16
June	11.7	15.9	8.6	26.9	5.1	19	10	8	5	11	21	11	14
July	14.8	19.5	11.5	27.2	9.3	16	28	14	12	8	6	9	8
August	15.6	20.2	12.5	27.4	9.2	16	9	9	14	19	14	9	9
September	14.5	18.6	11.2	26.9	5.5	6	5	2	16	23	19	15	14
October	9.6	12.4	6.9	18.3	-1.0	22	15	2	6	17	16	14	8
November	5.7	9.6	2.0	15.2	-7.1	6	10	11	13	12	18	23	6
December	-1.9	2.0	-5.5	11.7	-13.3	7	8	3	5	6	22	28	21
Average for 2005	5.9	Max 9.9	Min 2.4	**Extreme Max Avg** 27.4	**Extreme Min Avg** -24.0	18	13	7	10	11	14	14	13

*Each compass direction covers ±22.5 degrees.

4.27 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42-metre elevation (at the Point Lepreau Generating Station tower) contained a bias that affected the calculation of the Pasquill Stability factor. This does not affect the program. The compilation of the available 1986 to 2003 data have this information removed and are presented in Table 4.32. The meteorological data for 2005 were collected at ten minutes intervals and are presented in Table 4.31. Wind Rose data for 2005 are presented in Figure 4.24, and a pie-plot of the average percent frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.25.

Table 4.31: Meteorological Data for Point Lepreau (2005)

	Temperature (Degrees Celsius) 10 Metre Tower Data					*Wind Direction* (Relative %) 42 Metre Tower Data*							
		Mean Daily		*Extreme*		*%Observations from*							
Month	***Avg***	***Max***	***Min***	***Max***	***Min***	***N***	***NE***	***E***	***SE***	***S***	***SW***	***W***	***NW***
January	-8.1	-3.6	-12.5	10.6	-24.0	30	15	9	9	9	8	9	11
February	-3.7	0.1	-8.0	7.1	-19.2	26	11	7	6	7	15	14	14
March	-0.5	3.7	-4.2	10.8	-13.8	22	12	6	7	7	8	14	26
April	4.5	8.4	1.4	18.8	-2.1	24	16	8	12	9	9	10	12
May	7.6	11.1	5.0	14.5	-0.6	27	16	6	11	7	7	11	16
June	11.7	15.9	8.6	26.9	5.1	19	10	8	5	11	21	11	14
July	14.8	19.5	11.5	27.2	9.3	16	28	14	12	8	6	9	8
August	15.6	20.2	12.5	27.4	9.2	16	9	9	14	19	14	9	9
September	14.5	18.6	11.2	26.9	5.5	6	5	2	16	23	19	15	14
October	9.6	12.4	6.9	18.3	-1.0	22	15	2	6	17	16	14	8
November	5.7	9.6	2.0	15.2	-7.1	6	10	11	13	12	18	23	6
December	-1.9	2.0	-5.5	11.7	-13.3	7	8	3	5	6	22	28	21
Average for 2005	5.9	Max	Min	**Extreme Max Avg**	**Extreme Min Avg**	18	13	7	10	11	14	14	13
		9.9	2.4	27.4	-24.0								

*Each compass direction covers ±22.5 degrees.

Table 4.32: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Avg	Mean Daily		Extreme																	
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Extreme 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data

*Each wind direction covers ±22.5 degrees

Table 4.32: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Avg	Mean Daily		Extreme																	
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Extreme 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data

*Each wind direction covers ±22.5 degrees

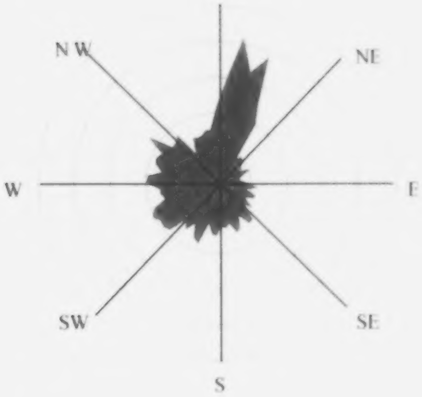


Figure 4.24: Wind Rose for Point Lepreau (2005)

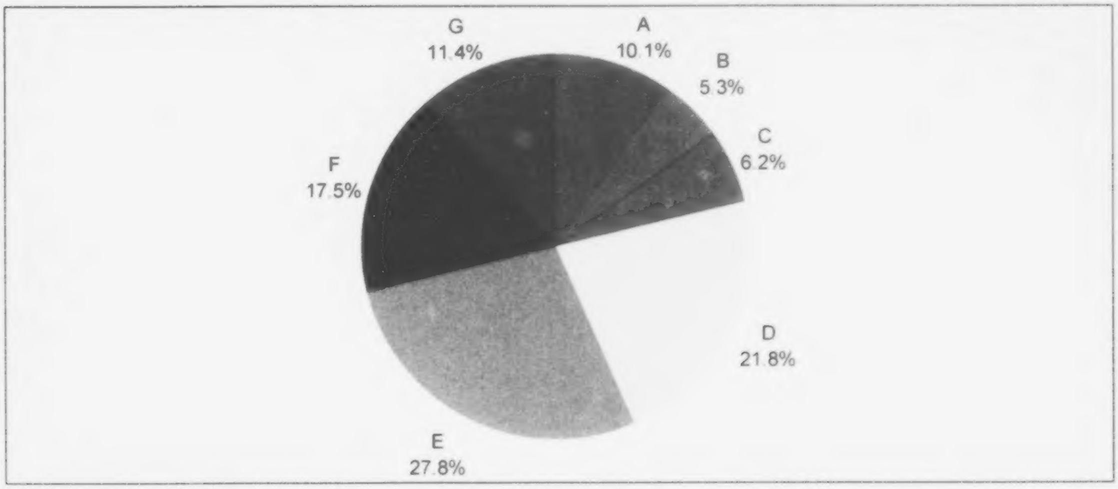


Figure 4.25: Pasquill Stability Factors for Point Lepreau (1986 to 1991)

5 Trends

The following trends were observed in the historical data:

- increasing concentration of tritium in Parshall Flume water from the Solid Radioactive Waste Management Facility (SRWMF) Phase 1. It is still below the peak concentration observed in 2000.
- continued low dose to members of the Critical Groups due to continued low emissions since 1995.
- continued low concentration of tritium in water vapour (onsite locations) since 1994.
- decreasing concentration of tritium in monitoring wells (near plant) since 2001.
- continuing detection of tritium in air and water samples (higher onsite than offsite).
- continuing difference between onsite and offsite thermoluminescent dosimeter (TLD) measurements.
- decreasing TLD measurements with distance from the SRWMF Phase 2 fence.

As in the figures in Section 4, "Less Than" values are plotted for non-detected values. All location codes are described in Appendix C.

5.01 Dose from Airborne and Liquid Pathways

Radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the design and operating target for PLGS (50 microsieverts per annum). Since 1995, there has been a generally decreasing trend in emissions (See Figure 5.01).

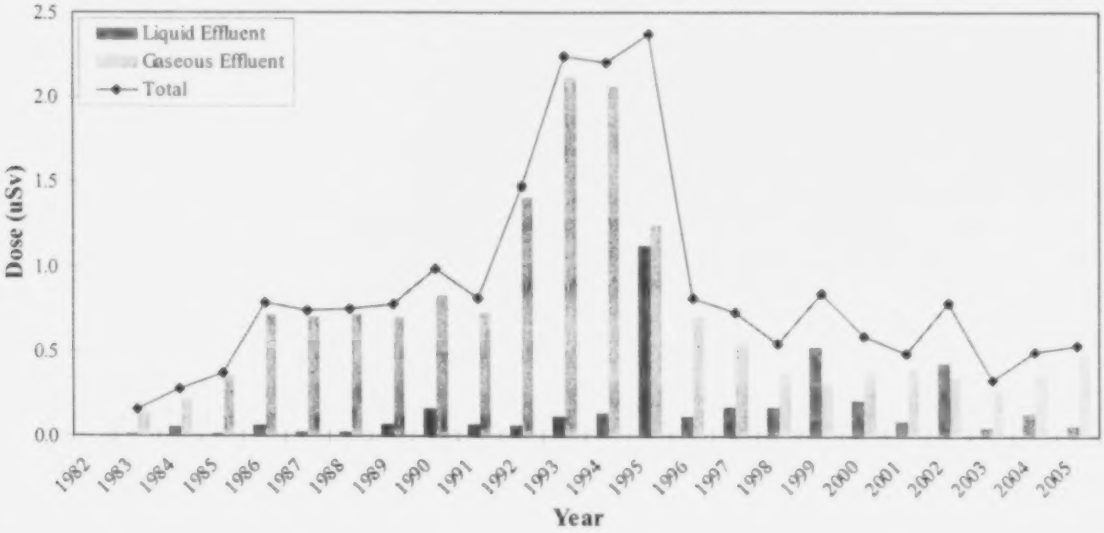


Figure 5.01: Dose from Airborne and Liquid Pathways

5.02 Gross Beta (Air Particulates)

Figures 5.02 and 5.03 show the gross beta data for all air stations since the NB Power Nuclear program began in 1976. A plot of the gross beta data from Dipper Harbour, about 4 km from the PLGS stack in the predominant downwind direction, is presented in Figure 5.04. The baseline data show the naturally occurring radioactivity in the area. The peaks on the plots correspond to fallout from various atmospheric bomb tests that were most common in the 1950s and 1960s but decreased into the 1970s. Fallout from the Chinese atmospheric bomb test in October of 1980 which impacted N.B. in 1981, and from the Chernobyl accident in April 1986, were detected. Figure 5.05 shows a comparable plot of data from Health and Welfare Canada, but for the whole of Canada from 1959 (when data were first collected) to 1991. The scale is condensed to allow the bomb test fallout levels to be kept on-scale.

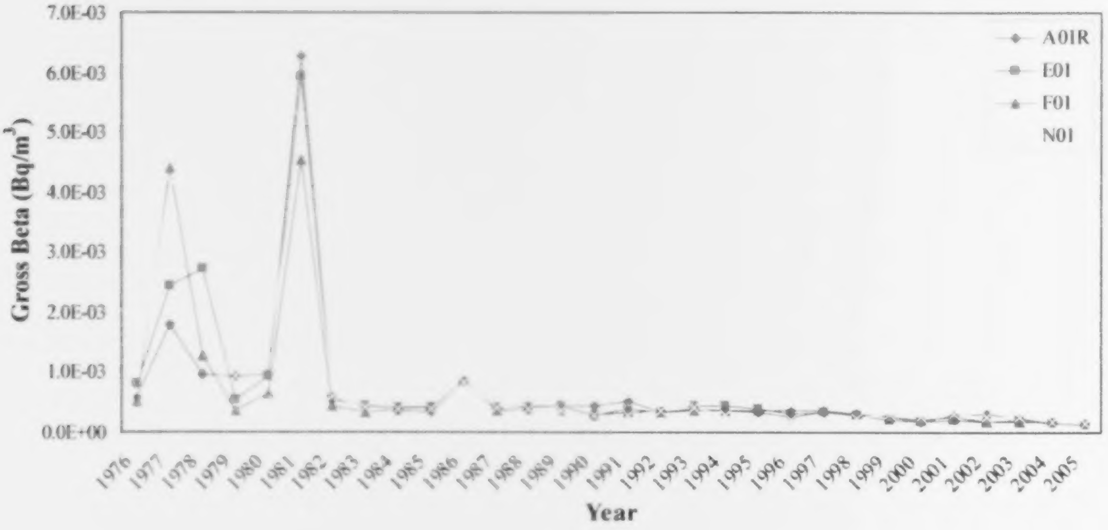


Figure 5.02: Gross Beta (Air Particulates) at Each Offsite Air Stations

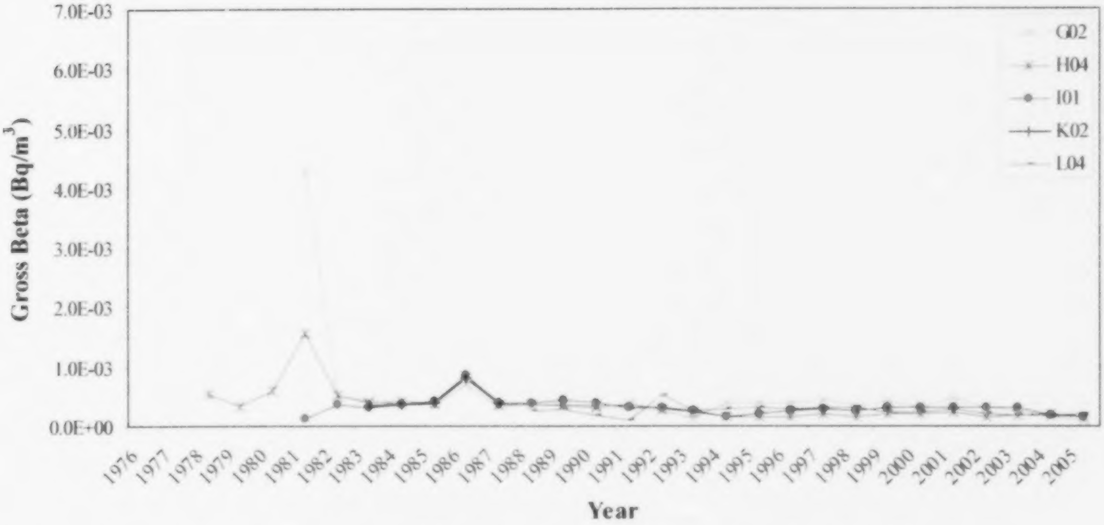


Figure 5.03: Gross Beta (Air Particulates) at Each Onsite Air Stations

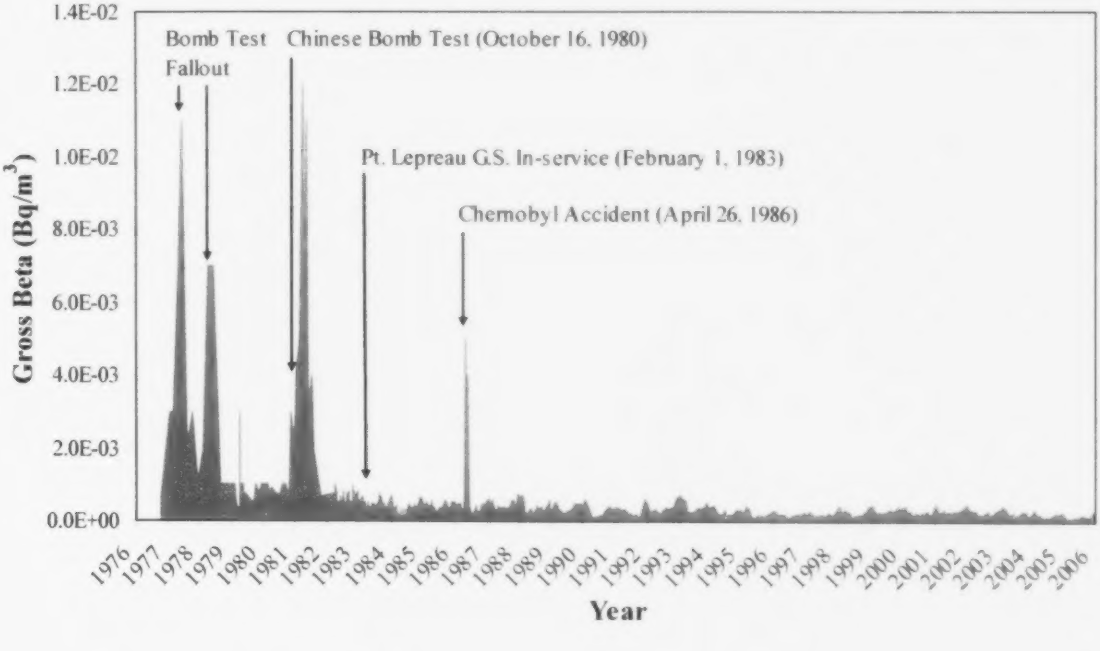


Figure 5.04: Gross Beta (Air Particulates) at Dipper Harbour

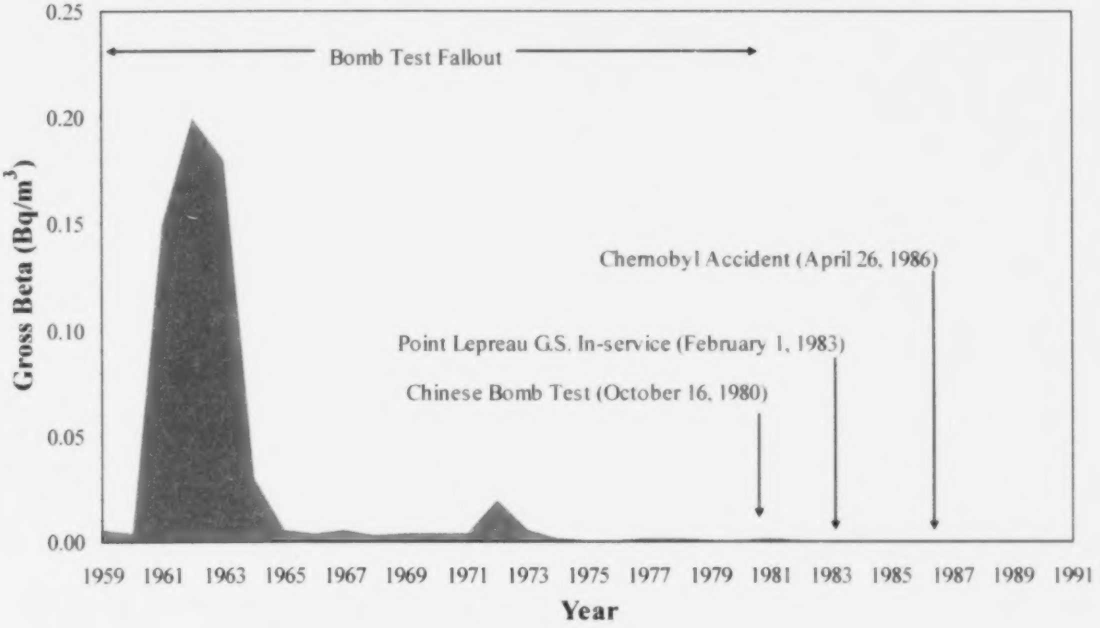
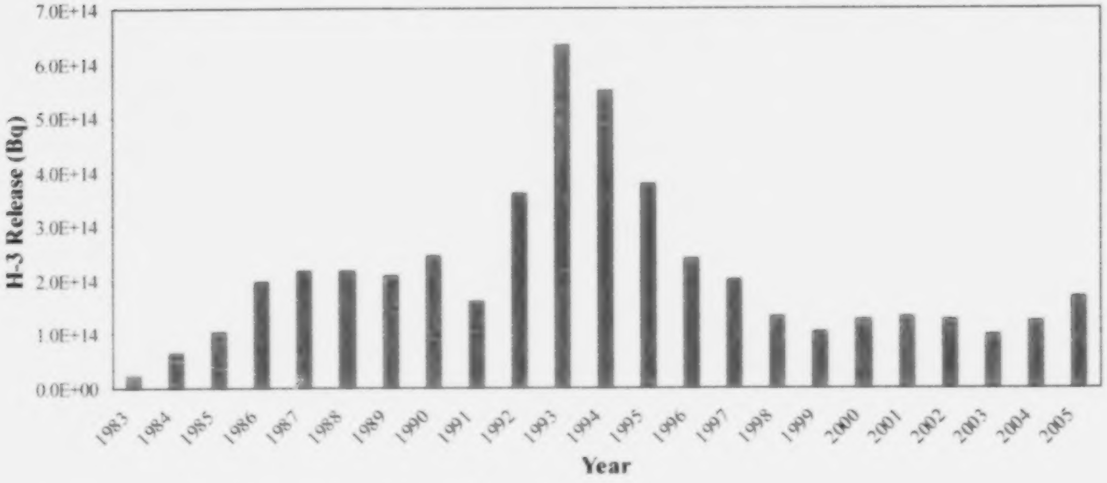


Figure 5.05: Annual Average Gross Beta (Air Particulates) for Canada 1959 to 1991 (Health and Welfare Canada Data)

5.03 Tritium (Water Vapour)

Station airborne tritium emissions have generally declined since their peak in 1993 (Figure 5.06). The onsite stations show a similar decline (Figures 5.07 and 5.09) in airborne H-3 concentration but still continue to be higher than the offsite locations (Figure 5.08). This is due to increasing dilution with distance from the emissions stack.



Note: The DEL for H-3 is 4.3E+17 Bq a^{-1}

Figure 5.06: Gaseous H-3 Emissions

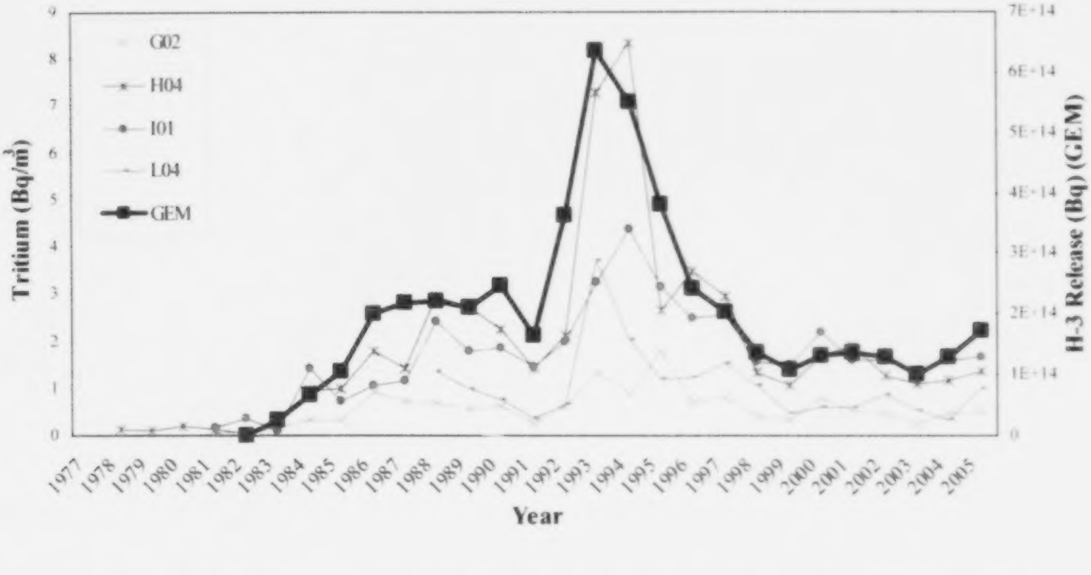


Figure 5.07: Gaseous H-3 Emissions and H-3 (Water Vapour) Results

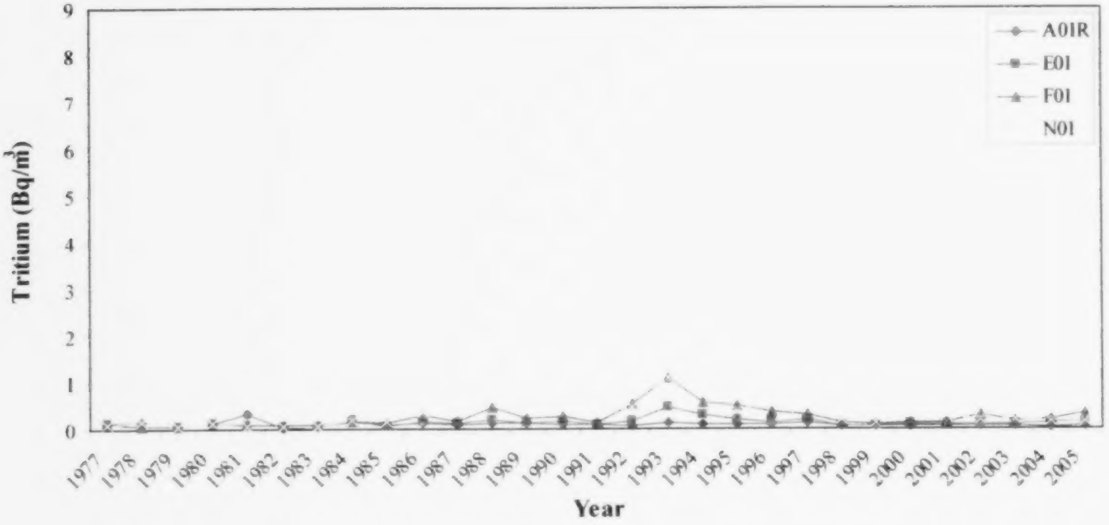


Figure 5.08: Tritium (Water Vapour) at Each Offsite Air Stations

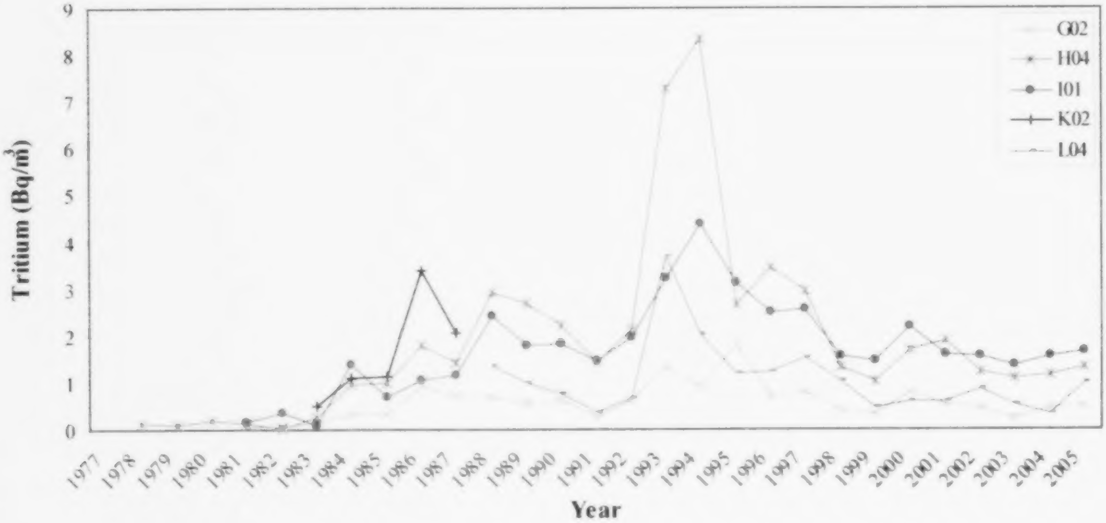


Figure 5.09: Tritium (Water Vapour) at Each Onsite Air Stations

5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions since 1984 is between 1E-07 and 2E-07 $s \cdot m^{-3}$. This factor is based upon the data for H-3. A value of 2E-07, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

The average recorded mean dispersion factor at each location, is now the average of the detected values and the "Less Than" values. This calculation will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

Each dispersion factor value is corrected to one kilometre to derive a normalised mean dispersion factor at one kilometre from the stack for all locations. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"(12). The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

Year	*Dispersion Factor ($s \cdot m^{-3}$)*
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
2001	2E-07
2002	2E-07
2003	2E-07
2004	2E-07
2005	2E-07
Average of 22 years	<2E-07

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

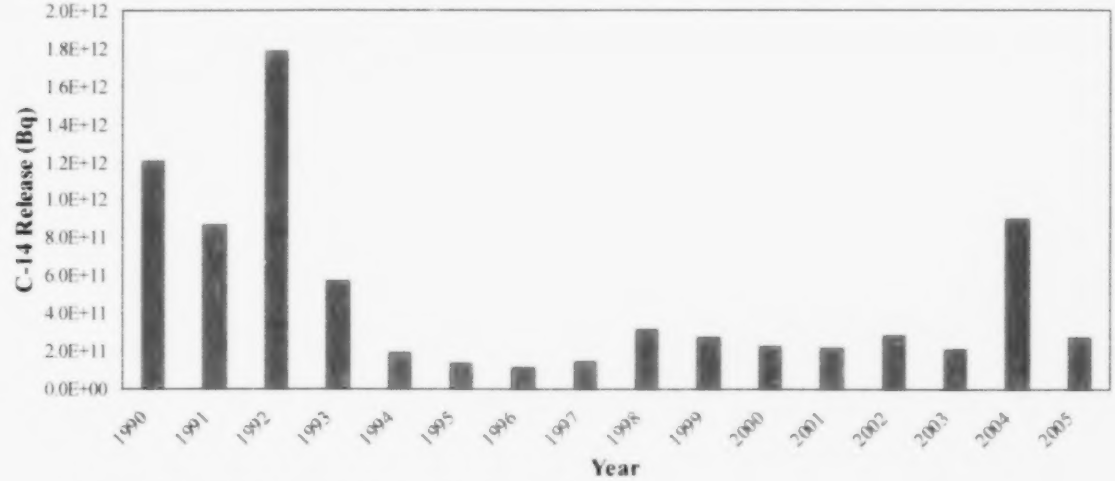
Location Code		**E01**	**F01**	**G02**	**H04**	**I01**	**K02**	**L04**	**N01**
Location		**Maces Bay**	**Welch Cove**	**Lepreau Lighthouse**	**Former Information Centre Site**	**SRWMF**	**CCW Pumphouse**	**Construction Stores**	**Dipper Harbour**
Distance from PLGS		**4.5 km**	**1.6 km**	**1.0 km**	**0.75 km**	**1.2 km**	**0.28**	**0.55 km**	**3.7 km**
Year	**Emission(Bq)**	**Dispersion Factor ($s \cdot m^{-3}$)**							
1984	6.80E+13	8E-08	8E-08	2E-07	5E-07	7E-7**	5E-07	-	8E-08
1985	1.10E+14	2E-08	4E-08	9E-08	3E-07	2E-07	3E-07	-	5E-08
1986	2.00E+14	3E-08	5E-08	1E-07	3E-07	2E-07	5E-07	-	6E-08
1987	2.20E+14	2E-08	2E-08	1E-07	2E-07	2E-07	3E-07	-	7E-08
1988	2.20E+14	3E-08	7E-08	1E-07	4E-07	3E-07	#	2E-07	9E-08
1989	2.10E+14	2E-08	4E-08	8E-08	4E-07	3E-07	#	2E-07	8E-08
1990	2.50E+14	2E-08	3E-08	8E-08	3E-07	2E-07	#	1E-07	8E-08
1991	1.70E+14	2E-08	3E-08	5E-08	3E-07	3E-07	#	7E-08	7E-08
1992	3.60E+14	2E-08	5E-08	5E-08	2E-07	2E-07	#	6E-08	4E-08
1993	6.40E+14	2E-08	5E-08	6E-08	4E-07	2E-07	#	2E-07	5E-08
1994	5.60E+14	2E-08	3E-08	5E-08	5E-07	2E-07	#	1E-07	1E-07
1995	3.10E+14	2E-08	5E-08	2E-07	3E-07	3E-07	#	1E-07	4E-08
1996	2.40E+14	2E-08	5E-08	9E-08	5E-07	3E-07	#	2E-07	8E-08
1997	2.10E+14	3E-08	5E-08	1E-07	4E-07	4E-07	#	2E-07	9E-08
1998	1.30E+14	2E-08	3E-08	1E-07	3E-07	4E-07	#	3E-07	5E-08
1999	9.50E+13	7E-08	5E-08	1E-07	3E-07	5E-07	#	1E-07	1E-07
2000	1.30E+14	2E-08	3E-08	2E-07	4E-07	5E-07	#	1E-07	8E-08
2001	1.30E+14	9E-08	5E-08	1E-07	4E-07	4E-07	#	1E-07	2E-07
2002	1.30E+14	2E-08	7E-08	1E-07	3E-07	4E-07	#	2E-07	5E-08
2003	1.00E+14	7E-08	2E-07	2E-07	2E-07	2E-07	#	3E-07	8E-08
2004	1.27E+14	1E-07	7E-08	1E-07	3E-07	4E-07	#	7E-08	1E-07
2005	1.71E+14	1E-07	8E-08	9E-08	2E-07	3E-07	#	2E-07	9E-08

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

# No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

5.05 Carbon-14 (Carbon Dioxide)

Station airborne C-14 emissions have declined since their peak in 1992 (Figure 5.10). Based on current stack emissions, the calculated average annual PLGS contibution to the concentration of C-14 in air at the boundary fence is less than 2E-03 Bq·m^{-3} (well below the natural level of 4E-02 Bq·m^{-3}). Only natural levels are detected at the air stations (Figure 5.11). The increase in 2004 was due to inefficiencies in the moderator purification system.



Note: The DEL for C-14 is 3.3E+15 Bq·a^{-1}

Figure 5.10: Gaseous C-14 Emissions

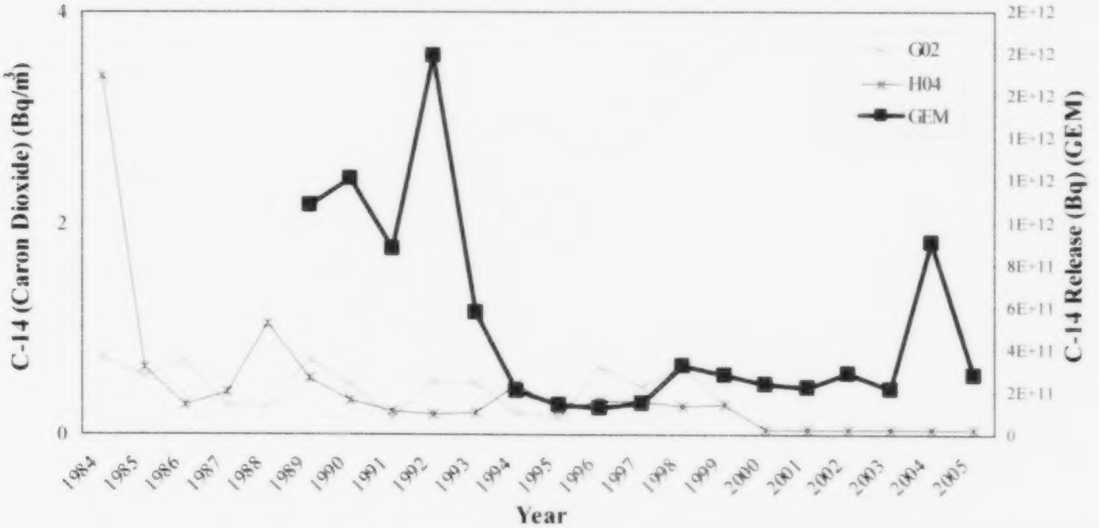


Figure 5.11: Gaseous C-14 Emissions and C-14 (Carbon Dioxide) for Onsite Air Stations

5.06 Ambient Gamma Measurements (TLD)

A plot of summary TLD data since 1977 is presented in Figure 5.12. There is only one reference location (A01R in Bocabec) while the other groups are the average of many locations. *Boundary* refers to locations at the edge of NB Power Nuclear property.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. A few locations (close to the reactor building and the air emissions stack) show significant, but small, increases in gamma radiation due to chronic emissions of low levels of noble gases. In 1995, the extended outage resulted in fewer noble gas emissions and thus lower dose measured by these TLDs. Small increases at the SRWMF are due to low-level waste and used fuel emplacement and not to station emissions.

Background radiation in any of the monitored residential areas has not increased from the levels measured before the Point Lepreau Generating Station was placed into operation.

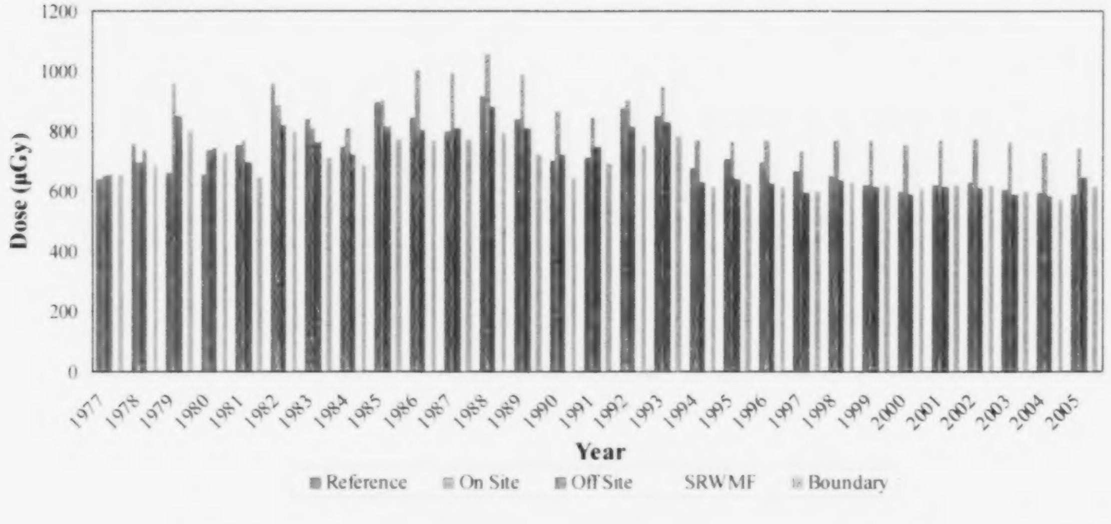
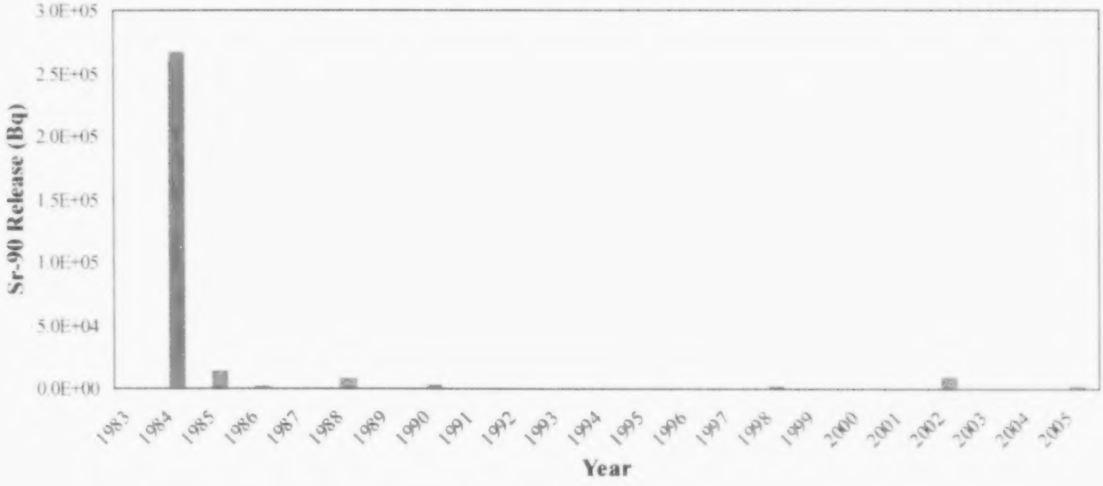


Figure 5.12: Ambient Gamma Measurements (TLD)

5.07 Strontium-90 (GEM Particulates)

There have only been a few years when Sr-90 was detected in station effluents (Figure 5.13). The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.



Note: The DEL for Sr-90 is 1.2E+13 Bq a^{-1}

Figure 5.13: Gaseous Sr-90 Emissions

5.08 Gross Beta (Well Water)

The beta activity in well water is due to the presence of naturally occurring radionuclides, especially radon progeny. There has been a slight increase in this parameter over the years (at both onsite and offsite locations).

The value plotted for each year in Figure 5.14 is the mean of all values for that year. "Less Than" values are plotted for non-detected values.

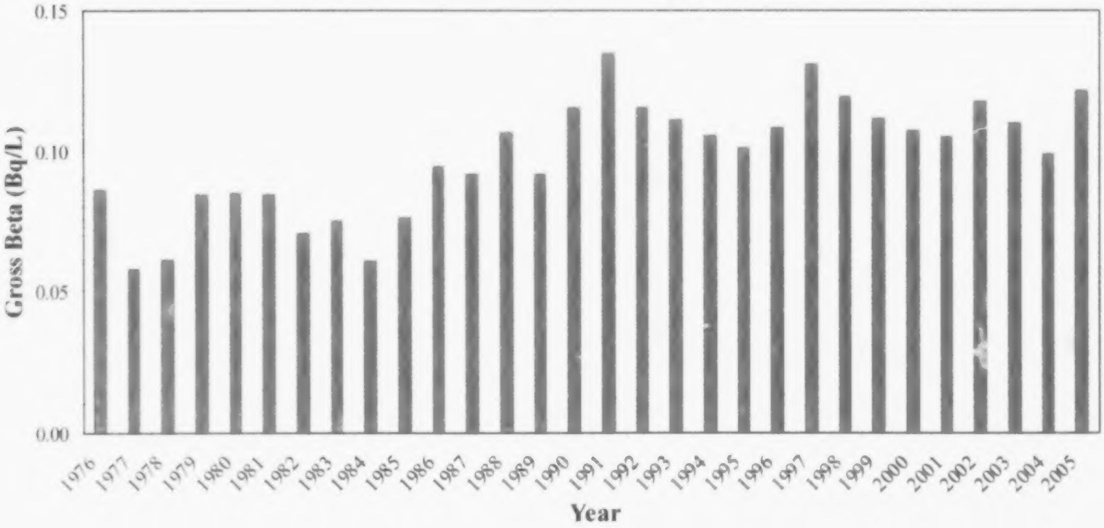


Figure 5.14: Gross Beta (Well Water)

5.09 Tritium (Well Water)

Precipitation and surface water contain H-3 from PLGS emissions. Even though there is surface runoff into some shallow wells, there has been no significant change in this parameter over the years.

The value plotted for each year in Figure 5.15 is the mean of all values for that year. "Less Than" values are plotted for non-detected values.

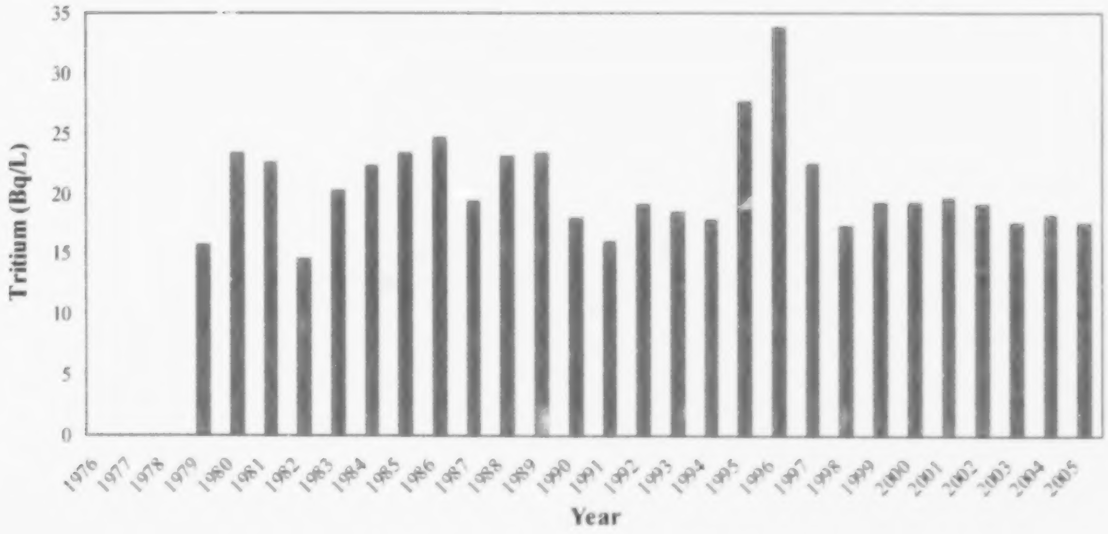


Figure 5.15: Tritium (Well Water)

5.10 Cesium-137 (Soil)

Cesium-137 from the fallout of past atmospheric bomb tests tends to accumulate in the organic layer of soil. Any fluctuation in Cs-137 levels seems to be due to this organic load in the sample. There were no soil samples collected from 1986 to 1992 because, at the time, this fluctuation caused soil to be viewed as an unimportant sample type.

The value plotted for each year in Figure 5.16 is the mean of all values for that year. "Less Than" values are plotted for non-detected values.

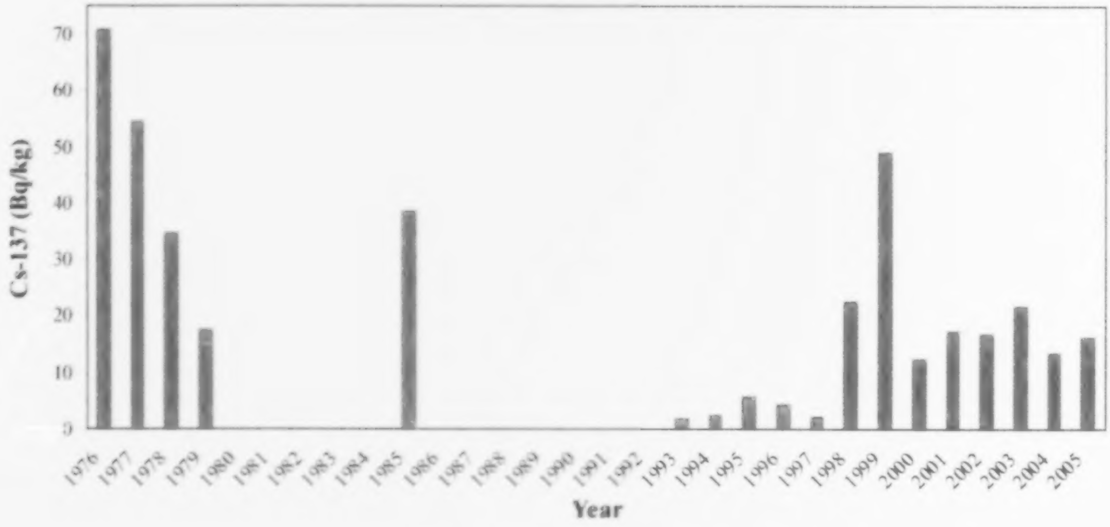


Figure 5.16: Cesium-137 (Soil)

5.11 Tritium (Monitoring Well Water, Near Plant)

The concentration of H-3 in monitoring wells (near plant) has been decreasing since 2001 (Figure 5.17).

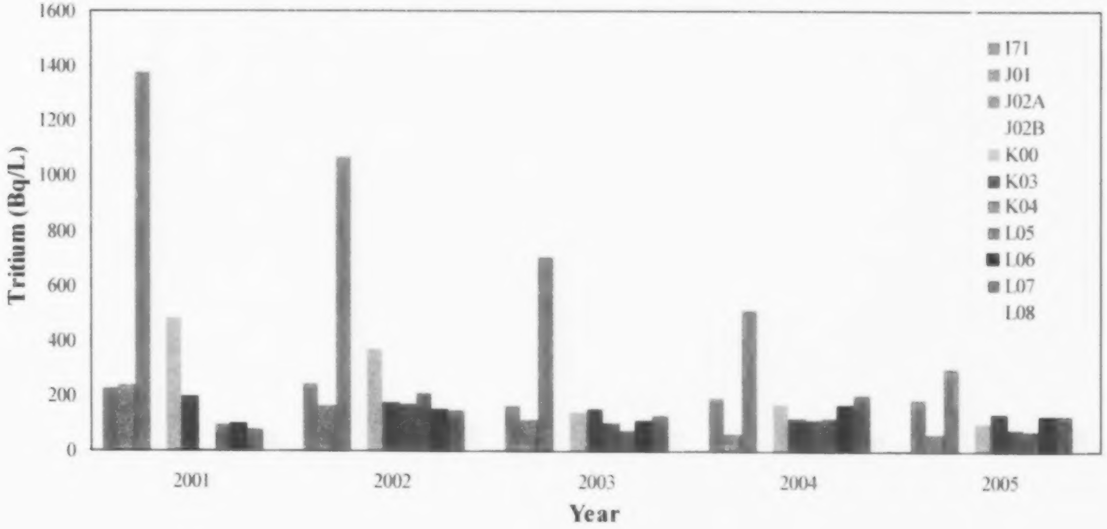


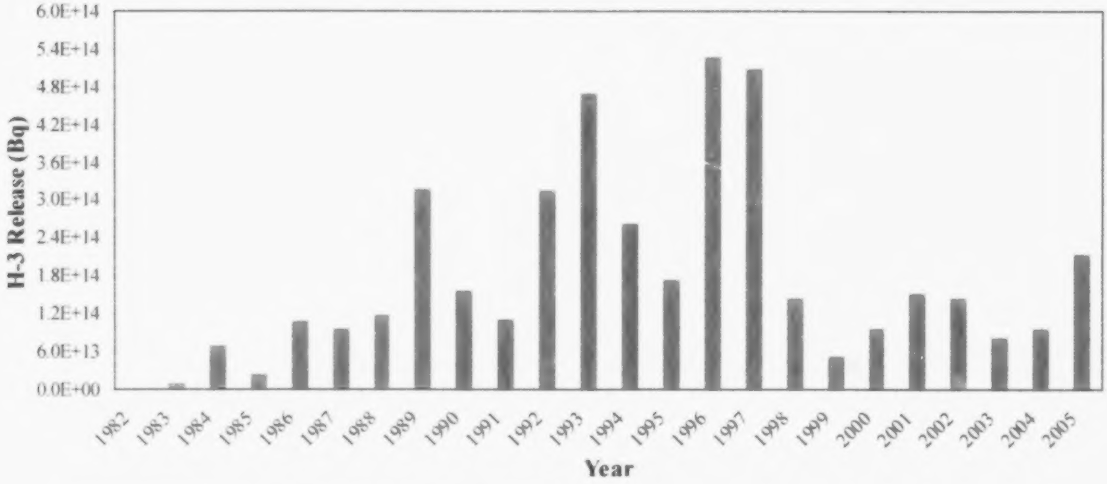
Figure 5.17: Tritium (Monitoring Well Water, Near Plant)

5.12 Tritium and C-14 (Seawater)

Tritium and C-14 emissions to seawater have been lower in recent years than they were at their peak in 1996 and 1997 (Figures 5.18 and 5.19).

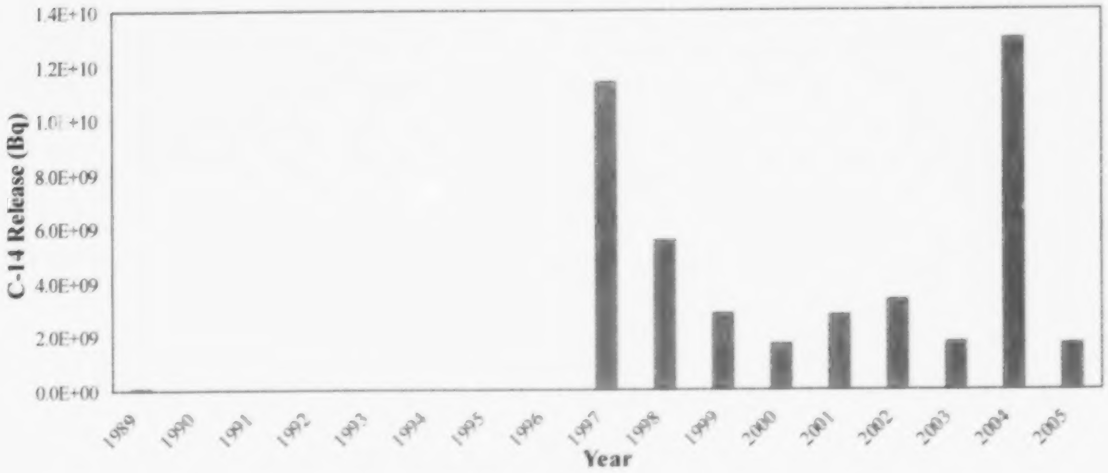
Tritium concentrations in seawater increased in 1996 and 1997 due to samples being taken directly over the out-fall. In other years, these samples have usually been taken at the shore, where the effects of tidal mixing are evident. The value plotted for each year in Figure 5.20 is the mean of all values for that year. "Less Than" values are plotted for non-detected values.

Since C-14 emissions are low, the expected concentration in seawater is below the detection limit. If the emission rate is more than 1% DEL, a C-14 analysis is performed on seawater. Since this has never happened, no further analyses were required.



Note: The DEL for H-3 is 1.6E+19 Bq a^{-1}

Figure 5.18: Liquid H-3 Emissions



Note: The DEL for C-14 is 3.0E+14 Bq a^{-1}

Figure 5.19: Liquid C-14 Emissions

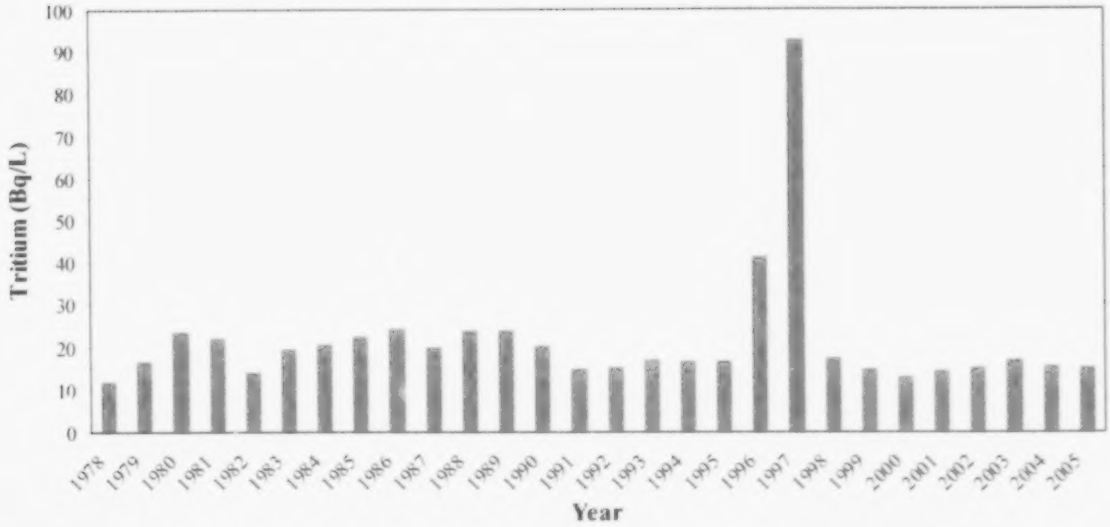


Figure 5.20: Tritium (Seawater)

5.13 Cesium-137 (Sediment)

The effects of the atmospheric bomb tests and the accident at Chernobyl continue to be seen in the Cs-137 load in the soil. There has been no significant change in this level over the years.

The value plotted for each year in Figure 5.21 is the mean of all values for that year. "Less Than" values are plotted for non-detected values.

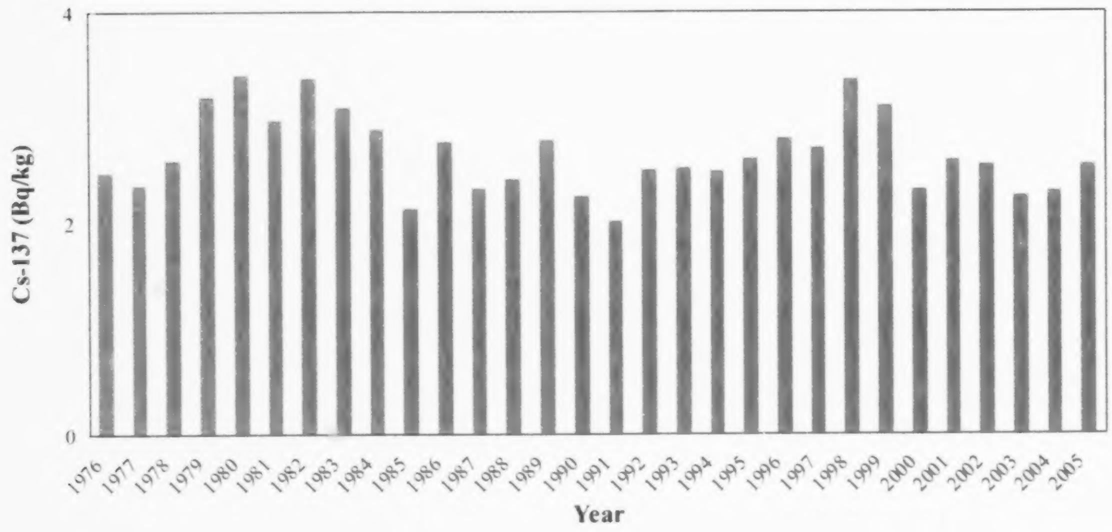
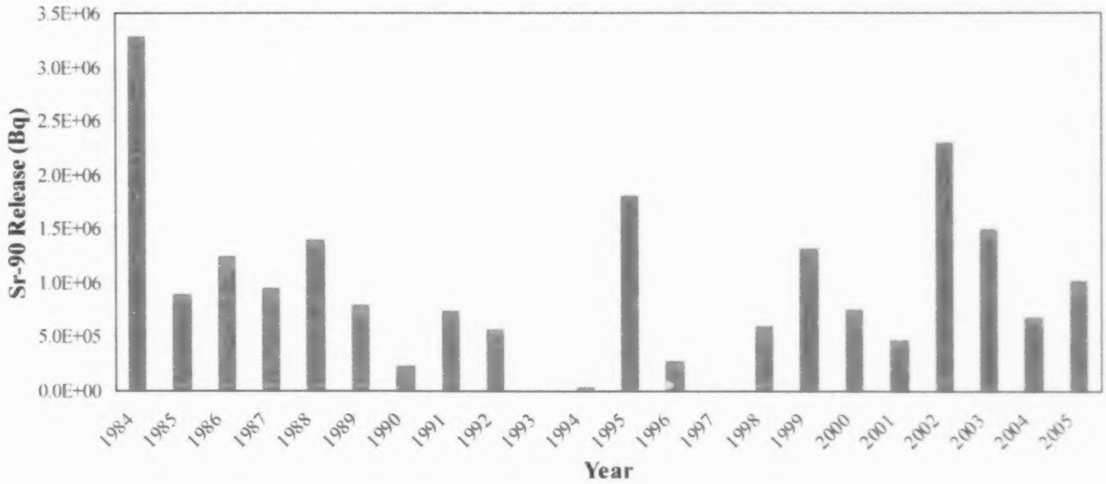


Figure 5.21: Cesium-137 (Sediment)

5.14 Strontium-90 (LEM Water)

The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit (Figure 5.22).



Note: The DEL for Sr-90 is 2.2E+15 Bq·a^{-1}

Figure 5.22: Liquid Sr-90 Emissions

5.15 Tritium (Bore Hole Water)

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new bore holes in and around the SRWMF (two older ones were retired) were drilled, bringing the total number of bore holes to 24. There has been a general upward trend in the Phase 1 H-3 results since the late 1980s. That trend was reversed in 2001 (Figures 5.23 to 5.27).

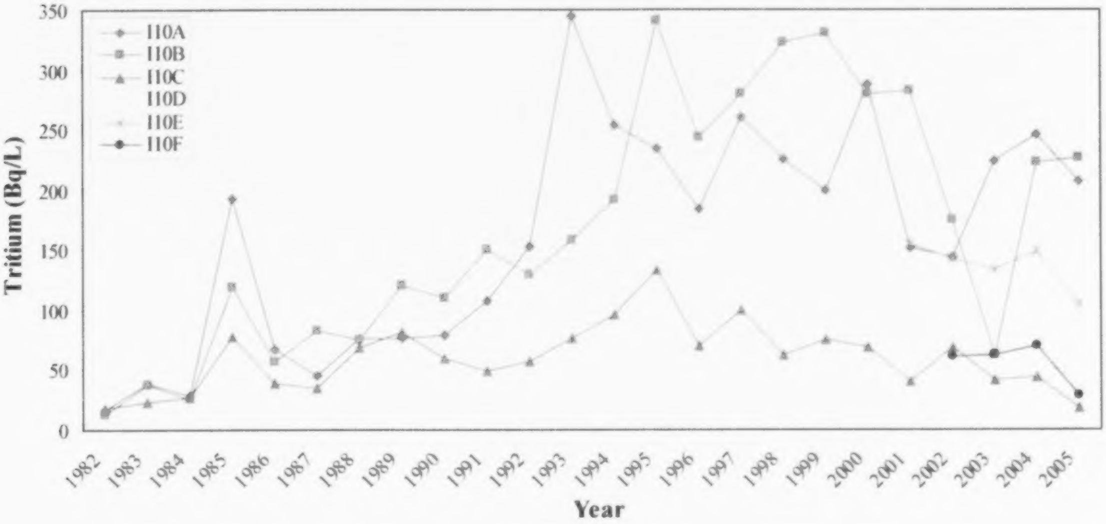


Figure 5.23: Tritium (Bore Hole Water, SRWMF – Phase 1)

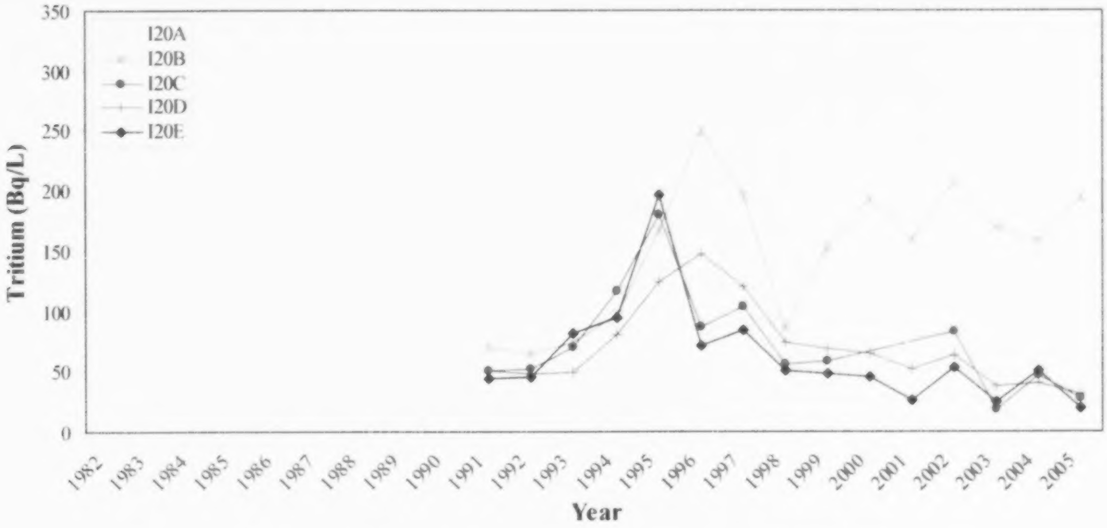


Figure 5.24: Tritium (Bore Hole Water, SRWMF - Phase 2)

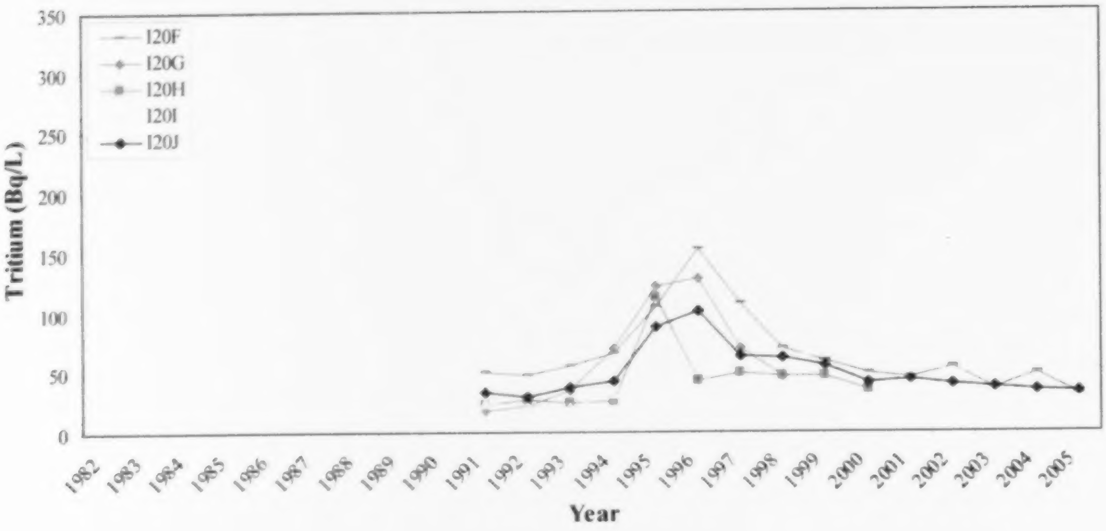


Figure 5.25: Tritium (Bore Hole Water, SRWMF - Phase 2)

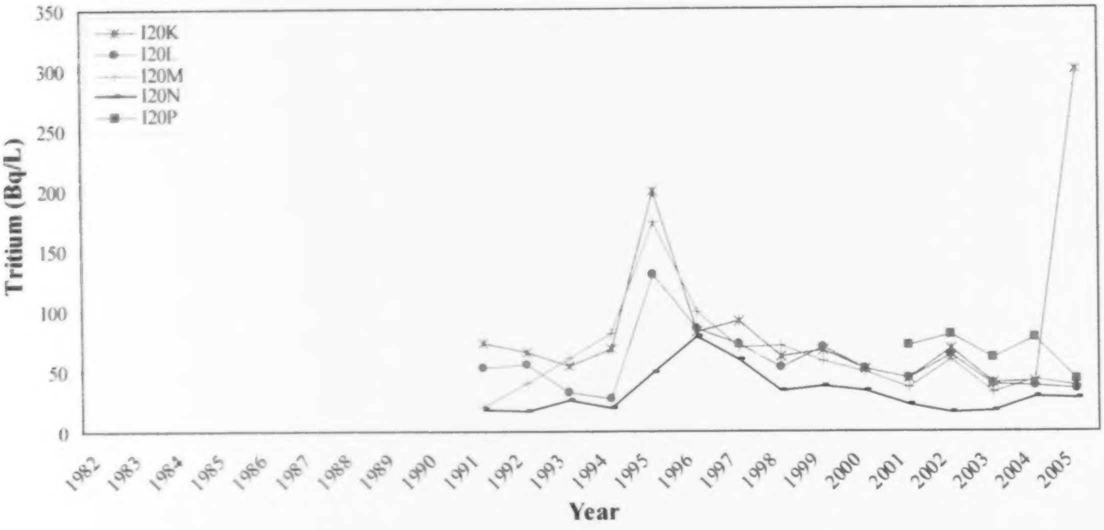


Figure 5.26: Tritium (Bore Hole Water, SRWMF - Phase 2)

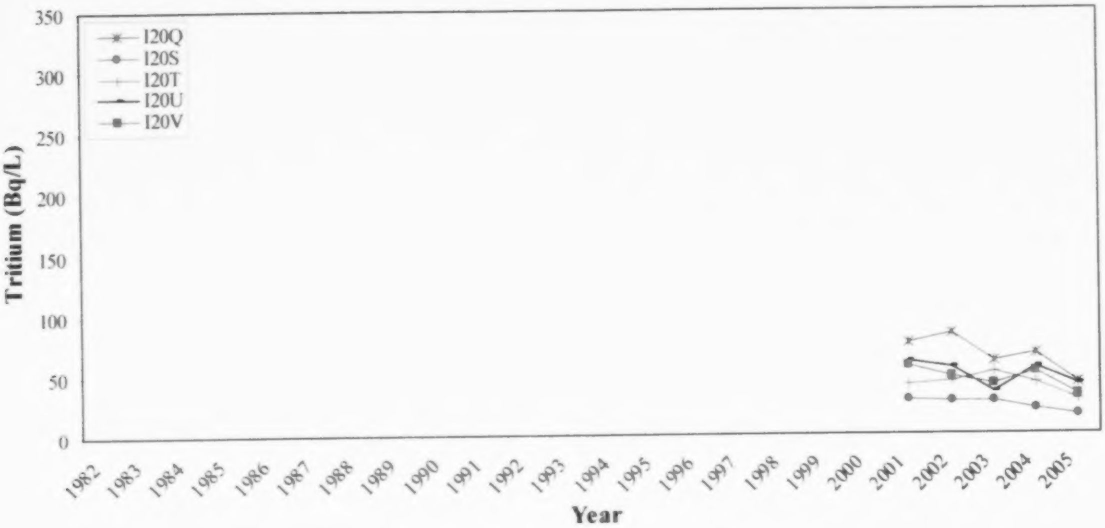


Figure 5.27: Tritium (Bore Hole Water, SRWMF - Phase 2)

5.16 Tritium (Parshall Flume Water)

The H-3 values at Phase 2 are typically less than those at Phase 1. The Phase 1 results are due to H-3 vapour escaping from the structures and condensing onto surfaces. There has been a general upward trend in the Phase 1 Parshall Flume H-3 results since the late 1980s. Although this trend was reversed in 2001, concentrations have been increasing since then. (Figure 5.28)

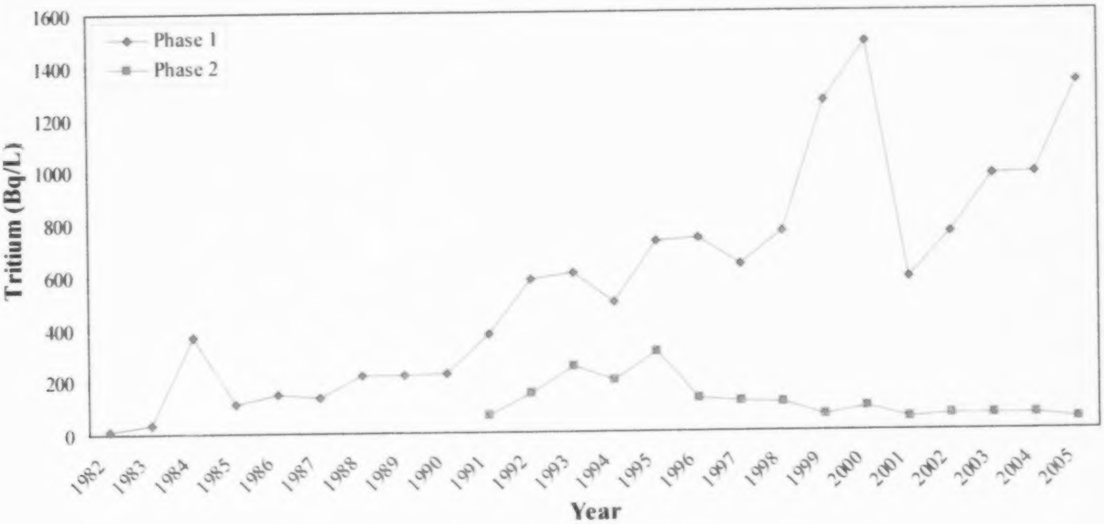


Figure 5.28: Tritium (Parshall Flume Water)

5.17 Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

Dosimeters are situated northeast ("A") and northwest ("B") from the boundary fence of the SRWMF - Phase 2 facility to a distance of about 100 m. These measure the decrease in radiation levels from the filled dry fuel storage canisters with distance. Results are presented in Figure 5.29. Each point on the graph is the average of all of the results collected since the facility has operated. The "B" direction shows higher radiation levels than the "A" direction because the mostly rocky terrain found in this direction has a higher natural background. The pattern of filling the canisters with spent fuel affects the reading on the first few TLDs in the "B" direction. In recent years, these TLDs have shown higher levels of radiation than the "A" TLDs because they are closer to full canisters. This trend has started to change as a new row of canisters, closer to the "A" TLDs, is currently being filled.

For 2005 and future years, data are only collected to 25 m in the "A" direction and 100 m in the "B" direction.

The bar charts in Figure 5.30 and Figure 5.31 present the annual dose for each location (since 1991).

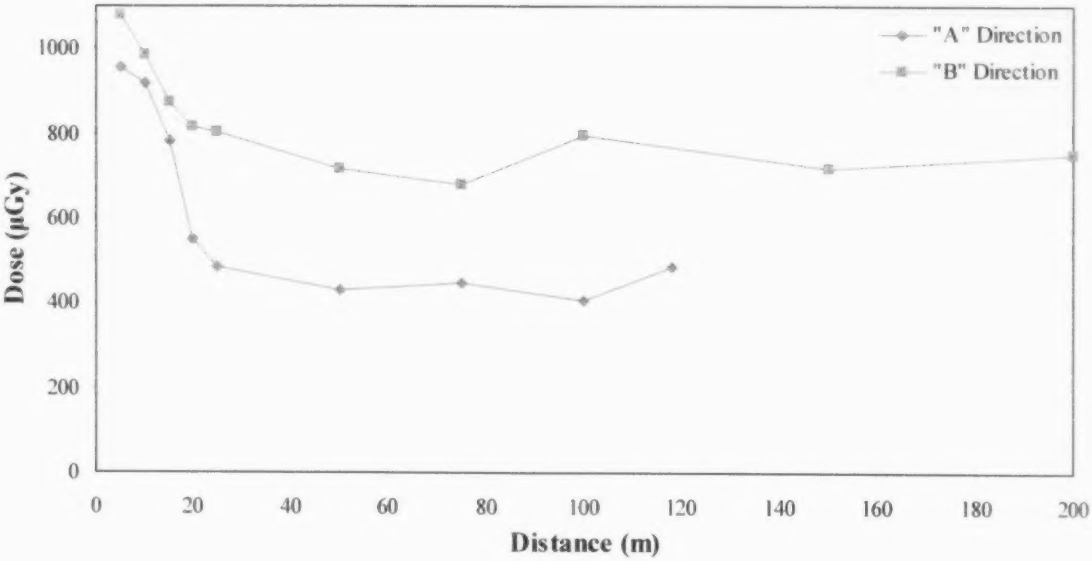


Figure 5.29: Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

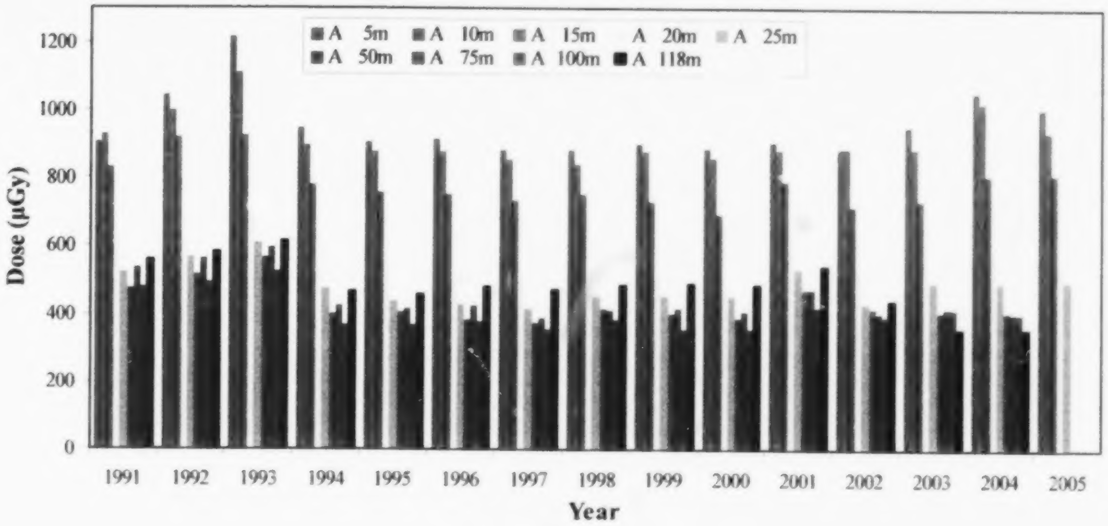


Figure 5.30: Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

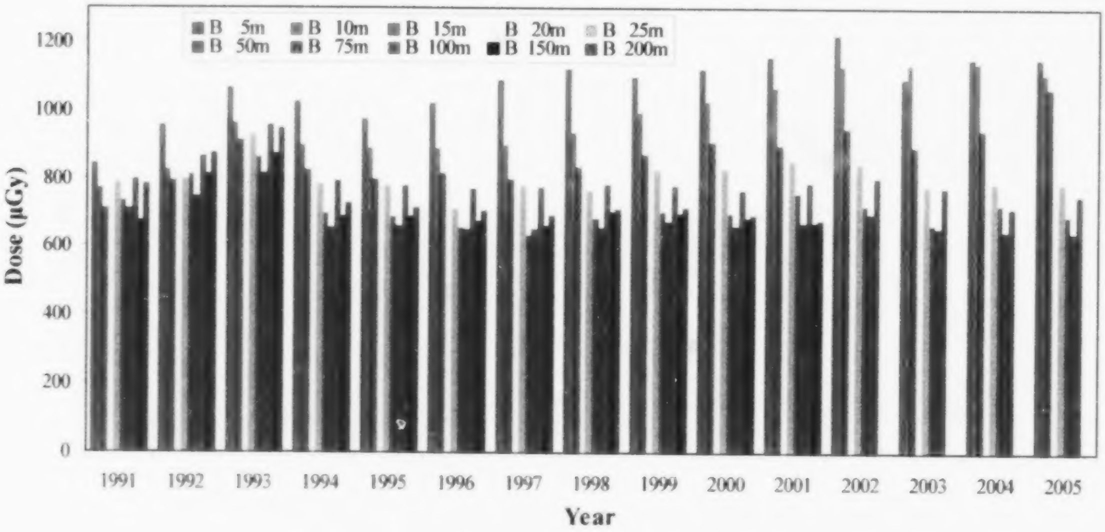


Figure 5.31: Ambient Gamma Measurements (TLD), Drop-off from SRWMF - Phase 2

6 Dose Estimation

For PLGS emissions, using a hypothetical Critical Group for each pathway was determined to be a more conservative approach than using an actual population centre such as Dipper Harbour. Within the two groups, the emission limit selected for each nuclide was the more restrictive one calculated for the adult or infant (one year old) member. The hypothetical Critical Groups are:

- Airborne – The members live continuously at a distance of 1 km from the stack. Depending on the member (adult or infant), some or all of their vegetables, meat, and milk are produced at 1.5 km from the stack, which is the distance to the nearest pasture.
- Liquid – The members are adults who are exposed to contaminated sediment while digging clams at Dipper Harbour, and who also eat above-average amounts of seafood (fish, lobster, clams, and dulse).

Based upon the total percent DEL for all monitored radionuclides in each pathway for 2005, the calculated annual whole body radiation dose to members of the Critical Groups was about 0.06 μSv from liquid emissions and about 0.48 μSv from airborne emissions. This latter calculation allows for the actual location of an existing dairy herd in 2005 at about 40 km, rather than assuming the existence of a hypothetical herd at 1.5 km. The result is a reduction in dose factor of about 12 for C-14 in the milk pathway because of the differences in dispersion factors between 1.5 km and 40 km (6E-08 $s \cdot m^{-3}$, and 5E-09 $s \cdot m^{-3}$, respectively).

Because of the protective assumptions used in the DEL calculations, and the relatively low level of emissions, the most exposed member of the general public received less than the calculated dose of 0.54 μSv. This radiation dose may be compared with the individual natural radiation dose in the Point Lepreau area of approximately 2000 to 3000 μSv per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000 μSv.) This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain radon levels that give a much larger radiation dose than the 2000 μSv quoted in the table. In addition, the average annual medical radiation dose is about 350 μSv per person.

Table 6.01: Annual Dose

Source of Dose to Critical Group	*Dose to Critical Group ($\mu Sv.a^{-1}$)*
PLGS airborne emissions	0.48
PLGS liquid emissions	0.06
natural background (estimate)	2 000
average medical dose (estimate)	350

The only assessable radiation dose from PLGS to the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples.

7 Quality Assurance Results

The purpose of Quality Assurance is to provide confidence in the program and demonstrate that the program is able to meet its objectives. QA is a system whereby the laboratory can assure the regulator, NB Power Nuclear, and the public that the laboratory is generating accurate and reproducible data. It encompasses:

- personnel
- procedures
- measurements
- sample integrity
- records
- annual review
- program audits
- program improvement

This section describes how QA was achieved for the year 2005. The specific procedures can be found in the *Quality Assurance* section of *Environmental Radiation Monitoring Program Procedures*(13).

7.01 Quality Control Checks

The four main pieces of analytical equipment used in the OERMP have a quality control (QC) check performed at the start of each working day. A background count is made each weekend to ensure the absence of contamination in the gamma spectrometer sample chamber. Key instrument parameters are checked and the results are compared against tolerance limits, and are also compared with previous results to detect trends in performance. This ensures that the parameters are consistent and remain free from significant drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for analytical work until the problem has been resolved. To perform the quality control checks, radiation sources traceable to US or Canadian standards (National Institute of Standards and Technology and National Research Council) are used.

The QC evaluations in the laboratory cover the following instruments:

1. Canberra Intrinsic Ge Gamma Spectrometer
2. Beckman LS 6000TA Liquid Scintillation Counter
3. Tennelec LB-5100 Gross Alpha/Beta Detector
4. Panasonic UD-710A TLD Reader

Throughout the year there were failures for each of the instruments. These failures involved only one of the seven to ten parameters monitored for each system. All of these failures were minor and were resolved on the same day they occurred.

Table 7.01: QC Passes & Failures

Instrument	*Number of Parameters Monitored Per Check*	*Number of Checks*	*Number of Individual Parameters Tested*	*Number of Individual Parameters Failed*
Canberra Intrinsic Ge Gamma Spectrometer	6	247	1482	8
Canberra Intrinsic Ge Gamma Spectrometer (Weekend Long Background)	8	50	400	16
Beckman LS 6000TA Liquid Scintillation Counter	10	267	2670	56
Tennelec LB-5100 Gross Alpha/Beta Detector	8	253	2024	20
Panasonic UD-710A TLD Reader	8	249	1992	0

7.01.01 Intrinsic Ge Gamma Spectrometer

A daily check of seven system parameters is performed for the germanium gamma spectroscopy system. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the cryostat (this parameter is not reflected in the numbers in Table 7.01). A computer program processes the results to generate QC plots and performs statistical tests to detect out-of-range values. A 200 000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. The QC program evaluates the total counts in eight separate regions of the background spectrum, and out-of-range values are flagged for assessment.

The efficiency calibration of the gamma spectroscopy system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

7.01.02 Beckman LS 6000TA Liquid Scintillation Counter

A set of sealed tritium, C-14 and background standards traceable to NIST is analysed daily. Statistical parameters must lie within defined limits or the equipment will not be used. These same standards are used to calibrate the instrument for each analysis run.

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7.01.03 Tennelec LB-5100 Gross Alpha/Beta Detector

Planchet standards of Am-241 and Sr-Y-90 are analysed daily. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta emissions on all samples analysed. Planchet and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

7.01.04 Panasonic UD-710A TLD Reader

A set of 16 TLDs is exposed in the Panarad Irradiator and read out in the TLD reader. The mean of each of the four elements, dark current, reference light, reference element, and lamp flashes must all be within specified limits. The QA aspect of this system is covered in detail in *External Beta/Gamma Dosimetry Program*(14).

7.01.05 Other Instruments

Other instruments (balances, pipettors) are checked or calibrated at least annually. See the *Calibration, Maintenance and Repair* section of *Environmental Radiation Monitoring Program Procedures*(13). Frequencies of calibration are based on reproducibility of measurements and on time stability tests to ensure that the measurements are within the specified tolerances for accuracy.

The gamma survey meters and contamination monitor are calibrated at PLGS on an annual basis.

7.02 External QA

The external quality assurance program consists of inter-comparisons with other laboratories to give independent verification of analytical performance. The frequency of each program may vary at the discretion of the sponsoring agency (see Table 7.02). Five such groups – CANDU Owners Group (COG), Analytics, Environmental Resource Associates (ERA), Radiation Protection Bureau of Health Canada (RPB) and the National Research Council (NRC) provide eight percent of the sample load in the laboratory with blind or semi-blind samples. Results of our performance with these samples give an indication of the quality of measurements the laboratory is capable of producing.

The number of External QA samples analysed was comparable to the previous year (95 samples in 2004 and 106 samples in 2005). See Table 7.02.

The results are tabulated by radionuclide in Table 7.03 and presented graphically in Figures 7.01 to 7.20. The same results are tabulated by medium in Tables 7.04 to 7.11. The tables show the sample date, while the figures show the analysis date.

The QA agent defines acceptable performance, generally in terms of an expected range. A failure signals the need to assess the procedures, analytical methods, or equipment calibrations.

There were 3 failures out of 200 tests on 106 samples in the external QA program:

- Gross Alpha in Water (ERA) – The failure was due to a combination of a programming error and operating outside the calibration range for the procedure.
- Cs-137 in Soil (ERA) – Even though the results for other gamma emitters in this sample passed, Cs-137 failed. The failure was caused by geometry problems associated with soil density.
- Cs-137 in Vegetation (ERA) – Even though the results for other gamma emitters in this sample passed, Cs-137 failed.

Table 7.02: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA Samples*	*External Agencies*
Filters	Gross Alpha/Beta	2	ERA
		2	Analytics
		2	COG
	Gamma	2	ERA
		2	Analytics
	Sr-89,90	2	ERA
		2	Analytics
Charcoal Cartridges	Gamma	4	Analytics
Environmental Gamma	TLD	10	NRC
Milk	Gamma	4	Analytics
Water	Gross Alpha/Beta	2	ERA
	H-3	4	COG
	C-14	4	COG
	Gamma	2	ERA
		2	COG
		2	Analytics
	Sr-89,90	2	ERA
		2	Analytics
Food/Vegetation	Gamma	2	ERA
Soil/Sediment	Gamma	2	ERA
		2	Analytics
Urine	H-3	30	RPB
	C-14	20	RPB
	Gamma	4	RPB

Table 7.03: Radionuclide Performance (External QA)

Analysis	Table No.	Sample Date	NB Power/Agent	All Participants
ALPHA (Figure 7.01)	7.04	2005-06-09	0.96	
	7.04	2005-12-08	0.90	
	7.04	2005-03-21	0.78	0.49 - 0.95
	7.04	2005-09-19	0.37	0.00 - 1.20
	7.09	2005-03-21	0.55 Fail	0.50 - 1.25
	7.09	2005-09-19	0.78	0.36 - 1.29
BETA (Figure 7.02)	7.04	2005-06-09	0.91	
	7.04	2005-12-08	0.93	
	7.04	2005-03-01	1.03	1.00 - 1.15
	7.04	2005-09-01	0.93	0.74 - 1.42
	7.04	2005-03-21	1.05	0.69 - 1.33
	7.04	2005-09-19	0.97	0.72 - 1.32
	7.09	2005-03-21	0.98	0.79 - 1.11
	7.09	2005-09-19	0.99	0.77 - 1.11
Am-241 (Figure 7.03)	7.04	2005-09-19	1.21	0.90 - 1.32
	7.09	2005-09-01	0.99	
	7.11	2005-03-21	0.69	0.42 - 1.38
	7.11	2005-09-19	0.65	0.60 - 1.10
C-14 (Figure 7.04)	7.07	2005-10-05	0.93	0.93 - 1.03
	7.07	2005-10-05	0.94	0.93 - 1.04
	7.07	2005-10-05	0.90	0.88 - 1.06
	7.09	2005-03-01	0.85	0.68 - 1.12
	7.09	2005-03-01	0.84	0.69 - 1.11
	7.09	2005-09-01	0.8	0.57 - 0.91
	7.09	2005-09-01	0.78	0.60 - 1.02
Cd-109 (Figure 7.03)	7.09	2005-03-01	1.00	0.93 - 1.14
	7.09	2005-09-01	1.00	0.97 - 1.15
Ce-139 (Figure 7.05)	7.09	2005-03-01	0.99	0.95 - 1.14
	7.09	2005-09-01	0.98	0.93 - 1.16

The QA agent defines acceptable performance, generally in terms of an expected range. A failure signals the need to assess the procedures, analytical methods, or equipment calibrations.

There were 3 failures out of 200 tests on 106 samples in the external QA program:

- Gross Alpha in Water (ERA) – The failure was due to a combination of a programming error and operating outside the calibration range for the procedure.
- Cs-137 in Soil (ERA) – Even though the results for other gamma emitters in this sample passed, Cs-137 failed. The failure was caused by geometry problems associated with soil density.
- Cs-137 in Vegetation (ERA) – Even though the results for other gamma emitters in this sample passed, Cs-137 failed.

Table 7.02: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA Samples*	*External Agencies*
Filters	Gross Alpha/Beta	2	ERA
		2	Analytics
		2	COG
	Gamma	2	ERA
		2	Analytics
	Sr-89,90	2	ERA
		2	Analytics
Charcoal Cartridges	Gamma	4	Analytics
Environmental Gamma	TLD	10	NRC
Milk	Gamma	4	Analytics
Water	Gross Alpha/Beta	2	ERA
	H-3	4	COG
	C-14	4	COG
	Gamma	2	ERA
		2	COG
		2	Analytics
	Sr-89,90	2	ERA
		2	Analytics
Food/Vegetation	Gamma	2	ERA
Soil/Sediment	Gamma	2	ERA
		2	Analytics
Urine	H-3	30	RPB
	C-14	20	RPB
	Gamma	4	RPB

Table 7.03: Radionuclide Performance (External QA)

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
ALPHA (Figure 7.01)	7.04	2005-06-09	0.96	
	7.04	2005-12-08	0.90	
	7.04	2005-03-21	0.78	0.49 - 0.95
	7.04	2005-09-19	0.37	0.00 - 1.20
	7.09	2005-03-21	0.55 Fail	0.50 - 1.25
	7.09	2005-09-19	0.78	0.36 - 1.29
BETA (Figure 7.02)	7.04	2005-06-09	0.91	
	7.04	2005-12-08	0.93	
	7.04	2005-03-01	1.03	1.00 - 1.15
	7.04	2005-09-01	0.93	0.74 - 1.42
	7.04	2005-03-21	1.05	0.69 - 1.33
	7.04	2005-09-19	0.97	0.72 - 1.32
	7.09	2005-03-21	0.98	0.79 - 1.11
	7.09	2005-09-19	0.99	0.77 - 1.11
Am-241 (Figure 7.03)	7.04	2005-09-19	1.21	0.90 - 1.32
	7.09	2005-09-01	0.99	
	7.11	2005-03-21	0.69	0.42 - 1.38
	7.11	2005-09-19	0.65	0.60 - 1.10
C-14 (Figure 7.04)	7.07	2005-10-05	0.93	0.93 - 1.03
	7.07	2005-10-05	0.94	0.93 - 1.04
	7.07	2005-10-05	0.90	0.88 - 1.06
	7.09	2005-03-01	0.85	0.68 - 1.12
	7.09	2005-03-01	0.84	0.69 - 1.11
	7.09	2005-09-01	0.8	0.57 - 0.91
	7.09	2005-09-01	0.78	0.60 - 1.02
Cd-109 (Figure 7.03)	7.09	2005-03-01	1.00	0.93 - 1.14
	7.09	2005-09-01	1.00	0.97 - 1.15
Ce-139 (Figure 7.05)	7.09	2005-03-01	0.99	0.95 - 1.14
	7.09	2005-09-01	0.98	0.93 - 1.16

Table 7.03 (continued): Radionuclide Performance (External QA)

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Ce-141 (Figure 7.06)	7.04	2005-06-09	1.10	
	7.04	2005-12-08	0.98	
	7.08	2005-03-17	0.93	
	7.08	2005-06-09	0.97	
	7.08	2005-09-15	0.97	
	7.08	2005-12-08	0.95	
	7.09	2005-03-17	0.95	
	7.09	2005-09-15	1.01	
	7.11	2005-12-08	0.86	
Co-57 (Figure 7.05)	7.09	2005-03-01	0.95	0.93 - 1.11
	7.09	2005-09-01	0.96	0.90 - 1.21
Co-58 (Figure 7.07)	7.04	2005-12-08	1.07	
	7.08	2005-03-17	0.98	
	7.08	2005-06-09	1.43	
	7.08	2005-09-15	0.97	
	7.08	2005-12-08	1.04	
	7.09	2005-03-17	1.01	
	7.09	2005-09-15	0.97	
	7.11	2005-12-08	0.89	
Co-60 (Figure 7.08)	7.04	2005-06-09	1.00	
	7.04	2005-12-08	1.02	
	7.04	2005-03-21	0.99	0.90 - 1.20
	7.04	2005-09-19	1.16	1.04 - 1.32
	7.08	2005-03-17	1.01	
	7.08	2005-06-09	1.02	
	7.08	2005-09-15	1.00	
	7.08	2005-12-08	1.00	
	7.09	2005-03-17	1.03	
	7.09	2005-09-15	1.00	

Table 7.03 (continued): Radionuclide Performance (External QA)

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Co-60 continued (Figure 7.08)	7.07	2005-09-07	0.94	0.95 - 1.07
	7.09	2005-03-01	0.99	0.91 - 1.12
	7.09	2005-09-01	1.00	0.95 - 1.06
	7.09	2005-03-21	0.98	0.92 - 1.14
	7.09	2005-09-19	0.98	0.89 - 1.13
	7.10	2005-03-21	0.94	0.85 - 1.13
	7.10	2005-09-19	0.93	0.77 - 1.16
	7.11	2005-06-09	1.00	
	7.11	2005-12-08	0.89	
Cr-51 (Figure 7.09)	7.04	2005-06-09	1.04	
	7.04	2005-12-08	1.20	
	7.08	2005-03-17	1.00	
	7.08	2005-06-09	1.00	
	7.08	2005-09-15	1.00	
	7.08	2005-12-08	1.02	
	7.09	2005-03-17	1.05	
	7.09	2005-09-15	1.12	
	7.11	2005-06-09	1.19	
Cs-134 (Figure 7.10)	7.04	2005-06-09	0.87	
	7.04	2005-12-08	0.86	
	7.04	2005-03-21	0.94	0.81 - 1.08
	7.04	2005-09-19	0.79	0.76 - 1.15
	7.08	2005-03-17	0.89	
	7.08	2005-06-09	1.03	
	7.08	2005-09-15	1.00	
	7.08	2005-12-08	1.10	
	7.09	2005-03-17	1.03	
	7.09	2005-09-15	0.89	
	7.09	2005-03-21	1.08	0.74 - 1.28
	7.09	2005-09-19	1.00	0.79 - 1.10
	7.11	2005-06-09	0.96	
	7.11	2005-12-08	0.93	

Table 7.03 (continued): Radionuclide Performance (External QA)

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cs-137 (Figure 7.11)	7.07	2005-09-07	0.95	0.95 - 1.09
	7.04	2005-06-09	1.03	
	7.04	2005-12-08	0.98	
	7.04	2005-03-21	1.02	0.85 - 1.31
	7.04	2005-09-19	1.00	0.96 - 1.26
	7.08	2005-03-17	1.02	
	7.08	2005-06-09	0.98	
	7.08	2005-09-15	1.01	
	7.08	2005-12-08	0.99	
	7.09	2005-03-17	0.87	
	7.09	2005-09-15	1.03	
	7.09	2005-03-01	1.00	0.94 - 1.12
	7.09	2005-09-01	1.01	0.98 - 1.08
	7.09	2005-03-21	0.97	0.92 - 1.14
	7.09	2005-09-19	1.08	0.81 - 1.17
	7.10	2005-03-21	0.85	0.79 - 1.29
	7.10	2005-09-19	0.80 Fail	0.82 - 1.16
	7.11	2005-06-09	0.90	
	7.11	2005-12-08	0.96	
	7.11	2005-03-21	0.82	0.66 - 1.36
	7.11	2005-09-19	0.77 Fail	0.79 - 1.20
Fe-59 (Figure 7.12)	7.04	2005-06-09	1.05	
	7.04	2005-12-08	1.12	
	7.08	2005-03-17	1.10	
	7.08	2005-06-09	1.03	
	7.08	2005-09-15	1.16	
	7.08	2005-12-08	1.16	
	7.09	2005-03-17	1.08	
	7.09	2005-09-15	1.04	
	7.11	2005-12-08	0.90	

Table 7.03 (continued): ***Radionuclide Performance (External QA)***

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Gamma (Figure 7.13)	7.06	2005-06-27	0.88	
	7.06	2005-11-30	0.89	
H-3 (Figure 7.14)	7.07	2005-04-14	0.91	0.82 - 1.10
	7.07	2005-04-14	0.83	0.67 - 1.09
	7.07	2005-04-14	0.91	0.81 - 1.13
	7.09	2005-03-01	1.01	0.99 - 1.10
	7.09	2005-03-01	0.97	0.94 - 1.07
	7.09	2005-09-01	0.94	0.91 - 1.06
	7.09	2005-09-01	0.95	0.94 - 1.04
Hg-203 (Figure 7.13)	7.09	2005-03-01	1.00	0.94 - 1.13
	7.09	2005-09-01	1.00	0.98 - 1.11
I-131 (Figure 7.15)	7.05	2005-03-17	0.97	
	7.05	2005-06-09	0.98	
	7.05	2005-09-15	0.94	
	7.05	2005-12-08	1.01	
	7.08	2005-03-17	1.05	
	7.08	2005-06-09	1.01	
	7.08	2005-09-15	1.20	
	7.08	2005-12-08	1.05	
	7.09	2005-03-17	1.23	
	7.09	2005-09-15	1.17	
K-40 (Figure 7.16)	7.10	2005-03-21	0.92	0.81 - 1.25
	7.10	2005-09-19	1.01	0.93 - 1.19
	7.11	2005-03-21	0.85	0.79 - 1.16
	7.11	2005-09-19	0.86	0.78 - 1.17
Mn-54 (Figure 7.17)	7.04	2005-06-09	1.16	
	7.04	2005-12-08	1.20	
	7.08	2005-03-17	1.01	
	7.08	2005-06-09	1.05	
	7.08	2005-09-15	1.05	
	7.08	2005-12-08	1.05	
	7.09	2005-03-17	1.03	
	7.09	2005-09-15	0.96	
	7.11	2005-06-09	0.98	
	7.11	2005-12-08	1.04	

Table 7.03 (continued): Radionuclide Performance (External QA)

Analysis	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Sn-113 (Figure 7.13)	7.09	2005-03-01	0.99	0.93 - 1.11
	7.09	2005-09-01	1.04	0.95 - 1.13
Sr-85 (Figure 7.18)	7.09	2005-03-01	1.00	0.96 - 1.10
	7.09	2005-09-01	1.02	0.85 - 1.26
Sr-89 (Figure 7.18)	7.04	2005-03-17	0.85	
	7.04	2005-09-15	0.72	
	7.09	2005-03-17	0.89	
	7.09	2005-09-15	0.96	
Sr-90 (Figure 7.19)	7.04	2005-03-17	0.85	
	7.04	2005-09-15	0.94	
	7.04	2005-03-21	0.75	0.58 - 1.24
	7.04	2005-09-19	0.93	0.85 - 1.06
	7.09	2005-03-17	0.91	
	7.09	2005-09-15	0.93	
	7.09	2005-03-21	0.81	0.86 - 1.09
	7.09	2005-09-19	0.94	0.77 - 1.29
Y-88 (Figure 7.16)	7.09	2005-03-01	1.00	0.92 - 1.12
	7.09	2005-09-01	1.00	0.97 - 1.06
Zn-65 (Figure 7.20)	7.04	2005-06-09	1.27	
	7.04	2005-12-08	1.24	
	7.08	2005-03-17	1.03	
	7.08	2005-06-09	1.05	
	7.08	2005-09-15	1.07	
	7.08	2005-12-08	1.12	
	7.09	2005-03-17	0.94	
	7.09	2005-09-15	1.00	
	7.11	2005-06-09	1.10	
	7.11	2005-12-08	0.85	

Table 7.04: Filter Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·filter^{-1} ± 2 sigma)	NB Power (Bq·filter^{-1} ± 2 sigma)	NB Power/ QA Agent (ratio)
ALPHA	2005-06-09	0.884 ± 0.029	0.851 ± 0.041	0.96
	2005-12-08	1.29 ± 0.04	1.16 ± 0.05	0.90
	2005-03-21	3.81 ± 0.19	2.96 ± 0.10	0.78
	2005-09-19	1.52 ± 0.21	0.570 ± 0.031	0.37
BETA	2005-06-09	3.63 ± 0.12	3.30 ± 0.11	0.91
	2005-12-08	7.03 ± 0.23	6.51 ± 0.18	0.93
	2005-03-01	11.1 ± 2.2	11.4 ± 0.3	1.03
	2005-09-01	5.50 ± 0.00	5.10 ± 0.15	0.93
	2005-03-21	2.83 ± 0.14	2.98 ± 0.10	1.05
	2005-09-19	0.888 ± 0.089	0.858 ± 0.038	0.97
Am-241	2005-09-19	7.03 ± 1.92	8.51 ± 0.73	1.21
Ce-141	2005-06-09	2.88 ± 0.10	3.17 ± 0.22	1.10
	2005-12-08	6.51 ± 0.22	6.40 ± 0.40	0.98
Co-58	2005-12-08	2.26 ± 0.08	2.41 ± 0.21	1.07
Co-60	2005-06-09	4.51 ± 0.15	4.51 ± 0.26	1.00
	2005-12-08	3.22 ± 0.11	3.30 ± 0.21	1.02
	2005-03-21	38.5 ± 1.9	38.1 ± 1.6	0.99
	2005-09-19	5.40 ± 0.59	6.29 ± 0.35	1.16
Cr-51	2005-06-09	9.44 ± 0.31	9.84 ± 0.92	1.04
	2005-12-08	5.62 ± 0.19	6.73 ± 0.72	1.20
Cs-134	2005-06-09	2.96 ± 0.10	2.56 ± 0.19	0.87
	2005-12-08	2.55 ± 0.08	2.20 ± 0.18	0.86
	2005-03-21	2.87 ± 0.14	2.71 ± 0.23	0.94
	2005-09-19	106 ± 8	83.6 ± 4.0	0.79
Cs-137	2005-06-09	5.88 ± 0.20	6.03 ± 0.41	1.03
	2005-12-08	5.51 ± 0.18	5.40 ± 0.38	0.98
	2005-03-21	24.1 ± 1.2	24.5 ± 1.5	1.02
	2005-09-19	78.8 ± 6.8	78.4 ± 4.5	1.00
Fe-59	2005-06-09	1.99 ± 0.07	2.09 ± 0.34	1.05
	2005-12-08	2.40 ± 0.08	2.69 ± 0.37	1.12
Mn-54	2005-06-09	3.89 ± 0.13	4.51 ± 0.34	1.16
	2005-12-08	4.44 ± 0.15	5.33 ± 0.38	1.20
Sr-89	2005-03-17	3.44 ± 0.11	2.93 ± 0.15	0.85
	2005-09-15	4.70 ± 0.16	3.39 ± 0.17	0.72
Sr-90	2005-03-17	0.577 ± 0.019	0.492 ± 0.042	0.85
	2005-09-15	0.370 ± 0.012	0.347 ± 0.034	0.94
	2005-03-21	7.18 ± 0.36	5.40 ± 0.12	0.75
	2005-09-19	10.7 ± 2.3	9.95 ± 0.40	0.93
Zn-65	2005-06-09	4.85 ± 0.16	6.18 ± 0.55	1.27
	2005-12-08	4.48 ± 0.15	5.55 ± 0.50	1.24

Table 7.05: Charcoal Cartridge Performance (External QA)

Analysis	Sample Date	QA Agent ($\text{Bq}\cdot\text{cartridge}^{-1}$ ± 2 sigma)	NB Power ($\text{Bq}\cdot\text{cartridge}^{-1}$ ± 2 sigma)	NB Power/QA Agent (ratio)
I-131	2005-03-17	2.23 ± 0.07	2.16 ± 0.18	0.97
	2005-06-09	3.39 ± 0.11	3.32 ± 0.36	0.98
	2005-09-15	2.36 ± 0.08	2.22 ± 0.15	0.94
	2005-12-08	2.71 ± 0.09	2.74 ± 0.48	1.01

Table 7.06: Environmental TLD Performance (External QA)

Analysis	Sample Date	QA Agent (mR ± 2 sigma)	NB Power (mR ± 2 sigma)	NB Power/QA Agent (ratio)
Gamma	2005-06-27	123 ± 1	109 ± 4	0.88
	2005-11-30	117 ± 1	104 ± 2	0.89

Table 7.07: Urine Performance (External QA)

Analysis	Sample Date	QA Agent ($\text{Bq}\cdot\text{L}^{-1}$ ± 2 sigma)	NB Power ($\text{Bq}\cdot\text{L}^{-1}$ ± 2 sigma)	NB Power/QA Agent (ratio)
C-14	2005-10-05	6950 ± 350	6460 ± 160	0.93
	2005-10-05	34500 ± 1700	32400 ± 800	0.94
	2005-10-05	5.7E+6 ± 2.9E+5	5.2E+6 ± 1.2E+4	0.90
Co-60	2005-09-07	291 ± 15	274 ± 13	0.94
Cs-137	2005-09-07	235 ± 12	223 ± 14	0.95
H-3	2005-04-14	59200 ± 3000	53700 ± 800	0.91
	2005-04-14	230000 ± 12000	190000 ± 2000	0.83
	2005-04-14	4.3E+6 ± 2.2E+5	3.9E+6 ± 7.3E+4	0.91

Table 7.08: Milk Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·L^{-1} ± 2 sigma)	NB Power (Bq·L^{-1} ± 2 sigma)	NB Power/ QA Agent (ratio)
Ce-141	2005-03-17	8.47 ± 0.28	7.84 ± 0.57	0.93
	2005-06-09	3.42 ± 0.11	3.32 ± 0.24	0.97
	2005-09-15	8.62 ± 0.29	8.36 ± 0.55	0.97
	2005-12-08	8.29 ± 0.28	7.88 ± 0.55	0.95
Co-58	2005-03-17	4.26 ± 0.14	4.18 ± 0.30	0.98
	2005-06-09	0.196 ± 0.007	0.281 ± 0.058	1.43
	2005-09-15	2.35 ± 0.08	2.27 ± 0.18	0.97
	2005-12-08	2.87 ± 0.10	2.99 ± 0.23	1.04
Co-60	2005-03-17	5.33 ± 0.18	5.40 ± 0.28	1.01
	2005-06-09	5.37 ± 0.18	5.48 ± 0.28	1.02
	2005-09-15	6.18 ± 0.21	6.18 ± 0.32	1.00
	2005-12-08	4.11 ± 0.14	4.11 ± 0.22	1.00
Cr-51	2005-03-17	12.4 ± 0.4	12.4 ± 1.1	1.00
	2005-06-09	11.2 ± 0.4	11.2 ± 1.0	1.00
	2005-09-15	12.5 ± 0.4	12.5 ± 1.0	1.00
	2005-12-08	7.14 ± 0.24	7.29 ± 0.73	1.02
Cs-134	2005-03-17	5.14 ± 0.17	4.59 ± 0.57	0.89
	2005-06-09	3.52 ± 0.12	3.63 ± 0.41	1.03
	2005-09-15	4.51 ± 0.15	4.51 ± 0.48	1.00
	2005-12-08	3.23 ± 0.11	3.57 ± 0.48	1.10
Cs-137	2005-03-17	4.81 ± 0.16	4.92 ± 0.34	1.02
	2005-06-09	6.99 ± 0.23	6.85 ± 0.46	0.98
	2005-09-15	7.22 ± 0.24	7.25 ± 0.48	1.01
	2005-12-08	6.99 ± 0.23	6.96 ± 0.47	0.99
Fe-59	2005-03-17	4.11 ± 0.14	4.51 ± 0.43	1.10
	2005-06-09	2.36 ± 0.08	2.45 ± 0.28	1.03
	2005-09-15	2.26 ± 0.08	2.61 ± 0.29	1.16
	2005-12-08	3.05 ± 0.10	3.54 ± 0.35	1.16
I-131	2005-03-17	3.42 ± 0.11	3.58 ± 0.32	1.05
	2005-06-09	3.22 ± 0.11	3.26 ± 0.24	1.01
	2005-09-15	3.49 ± 0.12	4.18 ± 0.99	1.20
	2005-12-08	2.76 ± 0.09	2.89 ± 0.22	1.05
Mn-54	2005-03-17	5.92 ± 0.20	5.96 ± 0.41	1.01
	2005-06-09	4.63 ± 0.15	4.85 ± 0.34	1.05
	2005-09-15	3.40 ± 0.11	3.56 ± 0.26	1.05
	2005-12-08	5.62 ± 0.19	5.92 ± 0.41	1.05
Zn-65	2005-03-17	7.33 ± 0.24	7.55 ± 0.57	1.03
	2005-06-09	5.74 ± 0.19	6.03 ± 0.48	1.05
	2005-09-15	4.55 ± 0.15	4.88 ± 0.41	1.07
	2005-12-08	5.70 ± 0.19	6.40 ± 0.48	1.12

Table 7.09: Water Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·L^{-1} ± 2 sigma) or (Bq·kg^{-1} ± 2 sigma)	NB Power (Bq·L^{-1} ± 2 sigma) or (Bq·kg^{-1} ± 2 sigma)	NB Power/ QA Agent (ratio)
ALPHA	2005-03-21	315 ± 16	174 ± 10	0.55 Fail
	2005-09-19	1180 ± 140	925 ± 33	0.78
BETA	2005-03-21	636 ± 32	625 ± 25	0.98
	2005-09-19	1790 ± 240	1780 ± 50	0.99
Am-241	2005-09-01	316000 ± 0	313000 ± 19000	0.99
C-14	2005-03-01	629000 ± 128000	533000 ± 14000	0.85
	2005-03-01	6.2E+6 ± 9.3E+5	5.2E+6 ± 1.3E+5	0.84
	2005-09-01	104000 ± 0	83300 ± 2100	0.80
	2005-09-01	7.4E+6 ± 0.0E+0	5.8E+6 ± 1.4E+5	0.78
Cd-109	2005-03-01	1.7E+6 ± 1.9E+5	1.7E+6 ± 1.2E+5	1.00
	2005-09-01	1.8E+6 ± 0.0E+0	1.8E+6 ± 1.0E+5	1.00
Ce-139	2005-03-01	88100 ± 6700	87300 ± 5100	0.99
	2005-09-01	144000 ± 0	141000 ± 8000	0.98
Ce-141	2005-03-17	8.18 ± 0.27	7.73 ± 0.71	0.95
	2005-09-15	10.4 ± 0.3	10.5 ± 0.9	1.01
Co-57	2005-03-01	69600 ± 5600	66200 ± 3900	0.95
	2005-09-01	68800 ± 0	66200 ± 3900	0.96
Co-58	2005-03-17	4.11 ± 0.14	4.14 ± 0.53	1.01
	2005-09-15	2.85 ± 0.10	2.75 ± 0.43	0.97
Co-60	2005-03-17	5.14 ± 0.17	5.29 ± 0.50	1.03
	2005-09-15	7.47 ± 0.25	7.44 ± 0.61	1.00
	2005-03-01	339000 ± 25000	334000 ± 14000	0.99
	2005-09-01	339000 ± 0	340000 ± 15000	1.00
	2005-03-21	109 ± 5	107 ± 5	0.98
	2005-09-19	197 ± 13	194 ± 8	0.98
Cr-51	2005-03-17	11.9 ± 0.4	12.5 ± 2.3	1.05
	2005-09-15	15.1 ± 0.5	16.8 ± 2.5	1.12
Cs-134	2005-03-17	4.96 ± 0.17	5.11 ± 0.58	1.03
	2005-09-15	5.48 ± 0.18	4.85 ± 0.52	0.89
	2005-03-21	4.74 ± 0.24	5.11 ± 0.72	1.08
	2005-09-19	39.6 ± 3.3	39.6 ± 2.4	1.00

Table 7.09 (continued): Water Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·L^{-1} ± 2 sigma) or (Bq·kg^{-1} ± 2 sigma)	NB Power (Bq·L^{-1} ± 2 sigma) or (Bq·kg^{-1} ± 2 sigma)	NB Power/ QA Agent (ratio)
Cs-137	2005-03-17	4.63 ± 0.15	4.03 ± 0.53	0.87
	2005-09-15	8.70 ± 0.29	8.95 ± 0.87	1.03
	2005-03-01	296000 ± 23000	295000 ± 17000	1.00
	2005-09-01	289000 ± 0	293000 ± 17000	1.01
	2005-03-21	83.3 ± 4.2	81.0 ± 5.1	0.97
	2005-09-19	9.95 ± 0.70	10.7 ± 1.1	1.08
Fe-59	2005-03-17	3.96 ± 0.13	4.29 ± 0.95	1.08
	2005-09-15	2.74 ± 0.09	2.86 ± 0.71	1.04
H-3	2005-03-01	92500 ± 13700	93600 ± 2400	1.01
	2005-03-01	5.8E+6 ± 4.5E+5	5.6E+6 ± 1.4E+5	0.97
	2005-09-01	133000 ± 0	125000 ± 3000	0.94
	2005-09-01	6.4E+6 ± 0.0E+0	6.1E+6 ± 1.5E+5	0.95
Hg-203	2005-03-01	236000 ± 22000	236000 ± 14000	1.00
	2005-09-01	239000 ± 0	238000 ± 14000	1.00
I-131	2005-03-17	2.44 ± 0.08	3.00 ± 0.48	1.23
	2005-09-15	2.89 ± 0.10	3.39 ± 0.49	1.17
Mn-54	2005-03-17	5.70 ± 0.19	5.85 ± 0.65	1.03
	2005-09-15	4.11 ± 0.14	3.96 ± 0.53	0.96
Sn-113	2005-03-01	326000 ± 26000	321000 ± 19000	0.99
	2005-09-01	332000 ± 0	345000 ± 19000	1.04
Sr-85	2005-03-01	437000 ± 29000	437000 ± 25000	1.00
	2005-09-01	415000 ± 0	422000 ± 25000	1.02
Sr-89	2005-03-17	3.81 ± 0.13	3.37 ± 0.17	0.89
	2005-09-15	5.29 ± 0.18	5.07 ± 0.23	0.96
Sr-90	2005-03-17	0.636 ± 0.021	0.581 ± 0.054	0.91
	2005-09-15	0.418 ± 0.014	0.389 ± 0.044	0.93
	2005-03-21	10.9 ± 0.5	8.84 ± 0.39	0.81
	2005-09-19	5.25 ± 0.56	4.92 ± 0.21	0.94
Y-88	2005-03-01	673000 ± 46000	673000 ± 28000	1.00
	2005-09-01	663000 ± 0	662000 ± 28000	1.00
Zn-65	2005-03-17	7.07 ± 0.24	6.66 ± 1.05	0.94
	2005-09-15	5.51 ± 0.18	5.51 ± 0.98	1.00

Table 7.10: Food/Vegetation Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·kg^{-1} ± 2 sigma)	NB Power (Bq·kg^{-1} ± 2 sigma)	NB Power/QA Agent (ratio)
Co-60	2005-03-21	86.2 ± 4.3	81.0 ± 5.5	0.94
	2005-09-19	16.0 ± 1.7	14.9 ± 1.8	0.93
Cs-137	2005-03-21	840 ± 42	718 ± 47	0.85
	2005-09-19	651 ± 56	518 ± 34	0.80 Fail
K-40	2005-03-21	818 ± 41	755 ± 72	0.92
	2005-09-19	1100 ± 110	1110 ± 90	1.01

Table 7.11: Soil Performance (External QA)

Analysis	Sample Date	QA Agent (Bq·kg^{-1} ± 2 sigma)	NB Power (Bq·kg^{-1} ± 2 sigma)	NB Power/ QA Agent (ratio)
Am-241	2005-03-21	99.9 ± 5.0	68.8 ± 7.9	0.69
	2005-09-19	44.0 ± 12.0	28.8 ± 4.6	0.65
Ce-141	2005-12-08	9.99 ± 0.33	8.62 ± 0.94	0.86
Co-58	2005-12-08	3.44 ± 0.11	3.07 ± 0.57	0.89
Co-60	2005-06-09	10.5 ± 0.4	10.5 ± 0.9	1.00
	2005-12-08	4.92 ± 0.16	4.37 ± 0.58	0.89
Cr-51	2005-06-09	22.1 ± 0.7	26.2 ± 4.7	1.19
Cs-134	2005-06-09	6.92 ± 0.23	6.62 ± 0.90	0.96
	2005-12-08	3.89 ± 0.13	3.61 ± 0.34	0.93
Cs-137	2005-06-09	17.5 ± 0.6	15.8 ± 1.5	0.90
	2005-12-08	12.2 ± 0.4	11.7 ± 1.2	0.96
	2005-03-21	1650 ± 80	1360 ± 80	0.82
	2005-09-19	272 ± 20	209 ± 13	0.77 Fail
Fe-59	2005-12-08	3.66 ± 0.12	3.30 ± 0.99	0.90
K-40	2005-03-21	992 ± 50	847 ± 60	0.85
	2005-09-19	1020 ± 90	877 ± 61	0.86
Mn-54	2005-06-09	9.10 ± 0.30	8.95 ± 1.05	0.98
	2005-12-08	6.77 ± 0.23	7.07 ± 0.89	1.04
Zn-65	2005-06-09	11.3 ± 0.4	12.5 ± 1.8	1.10
	2005-12-08	6.85 ± 0.23	5.81 ± 0.79	0.85

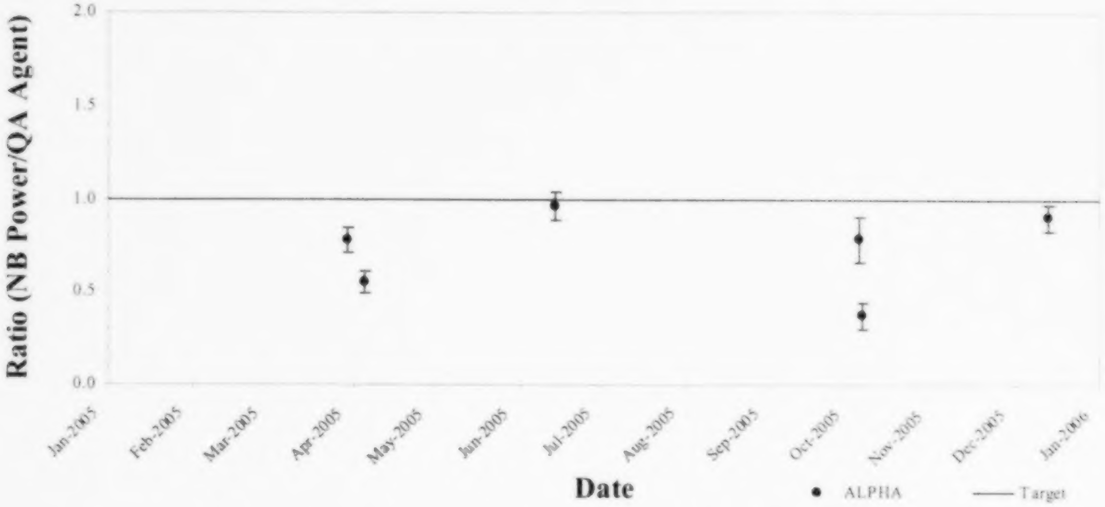

Figure 7.01: Alpha Performance (External QA)

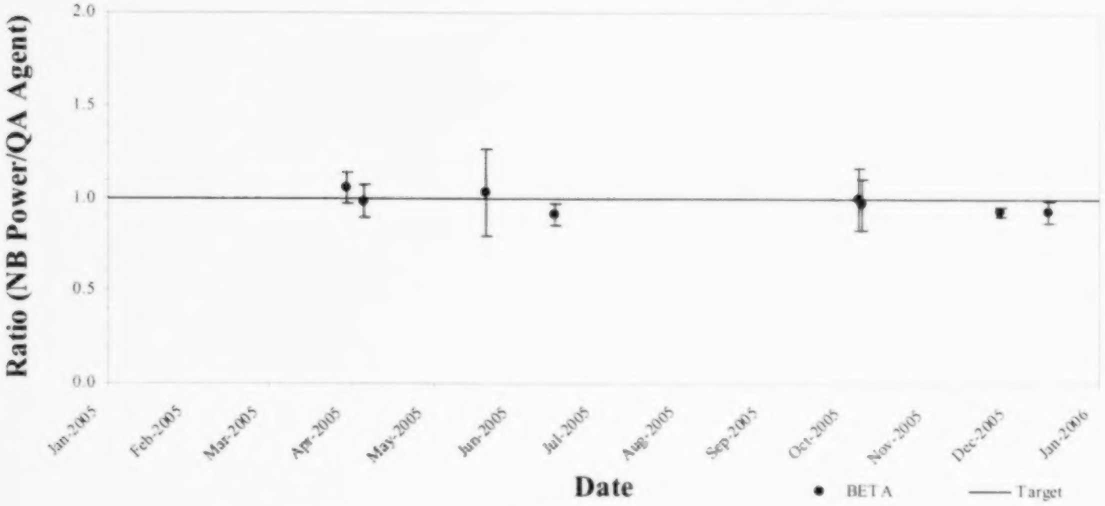

Figure 7.02: Beta Performance (External QA)

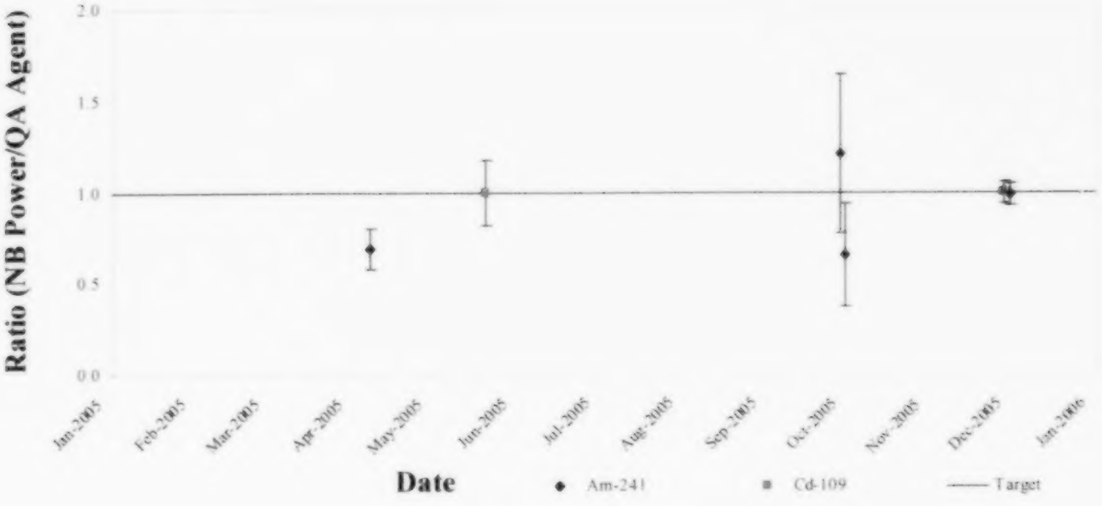

Figure 7.03: Americium-241and Cd-109 Performance (External QA)

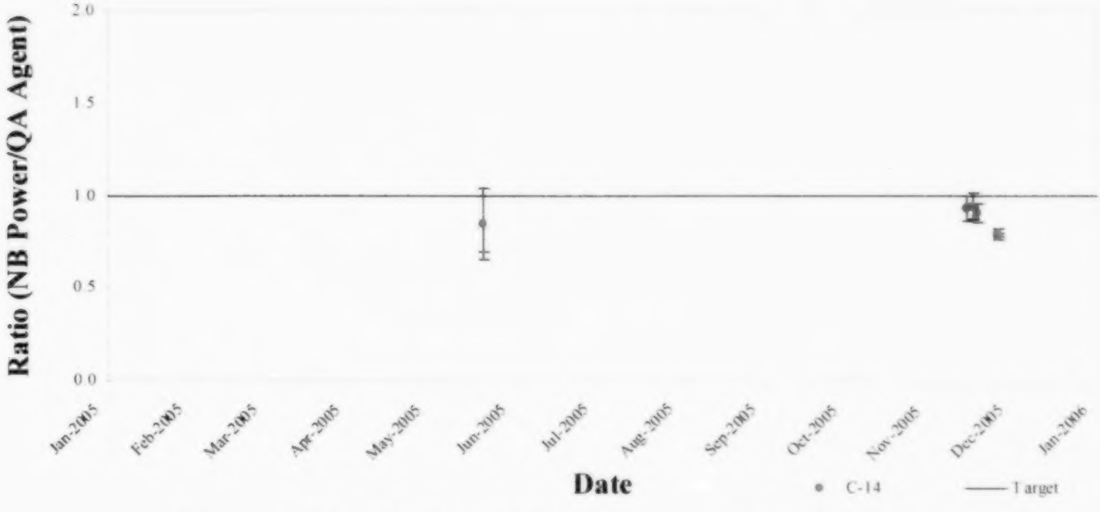

Figure 7.04: Carbon-14 Performance (External QA)

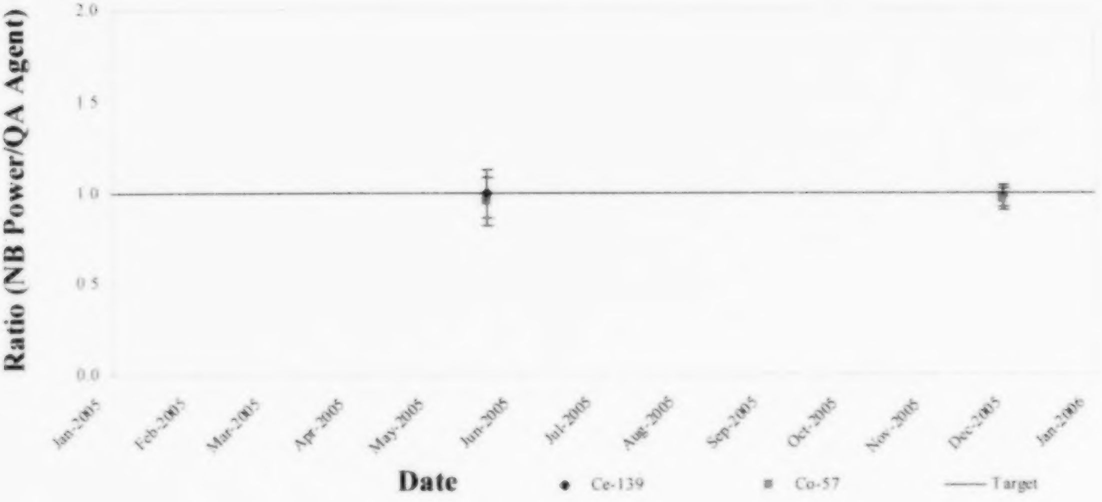

Figure 7.05: Cerium-139 and Co-57 Performance (External QA)

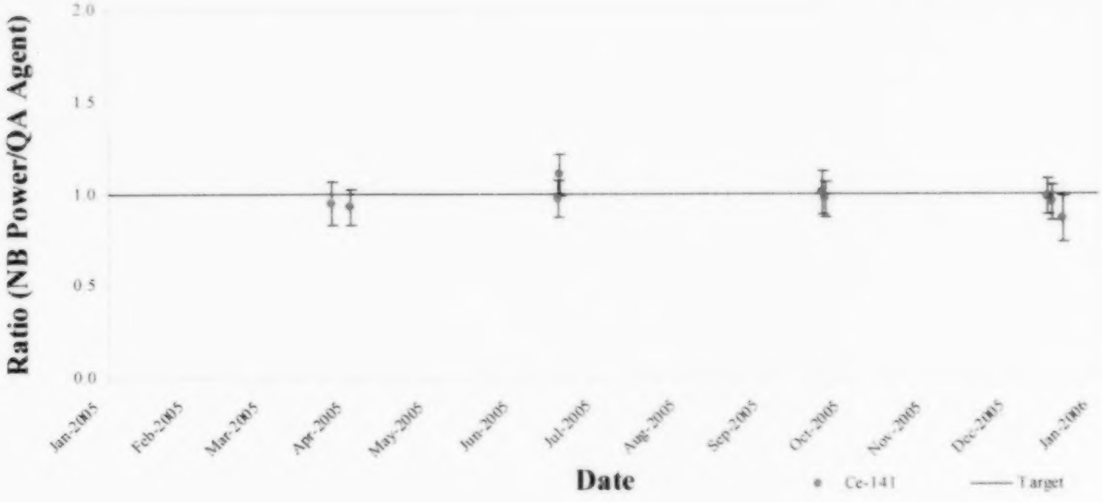

Figure 7.06: Cerium-141 Performance (External QA)

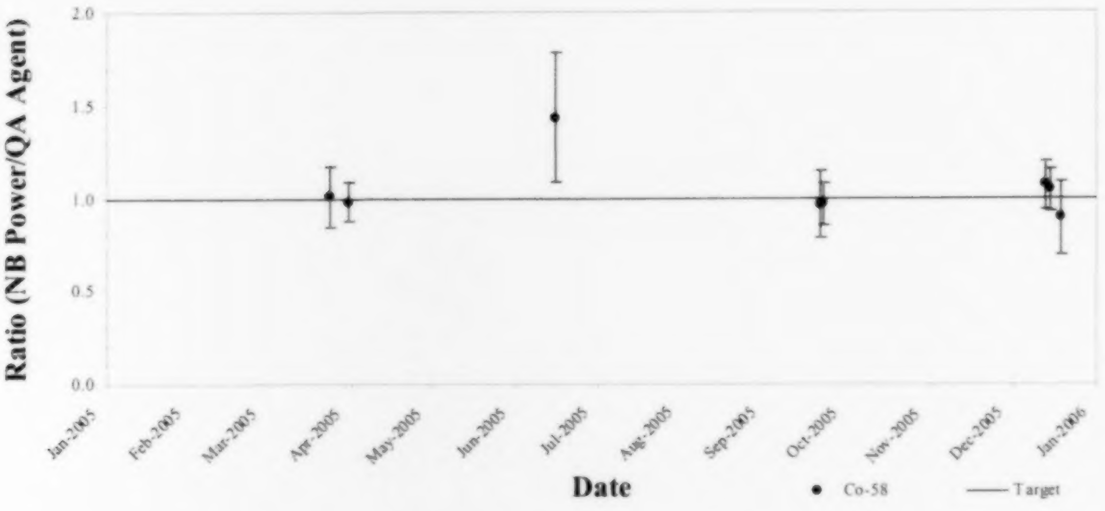

Figure 7.07: Cobalt-58 Performance (External QA)

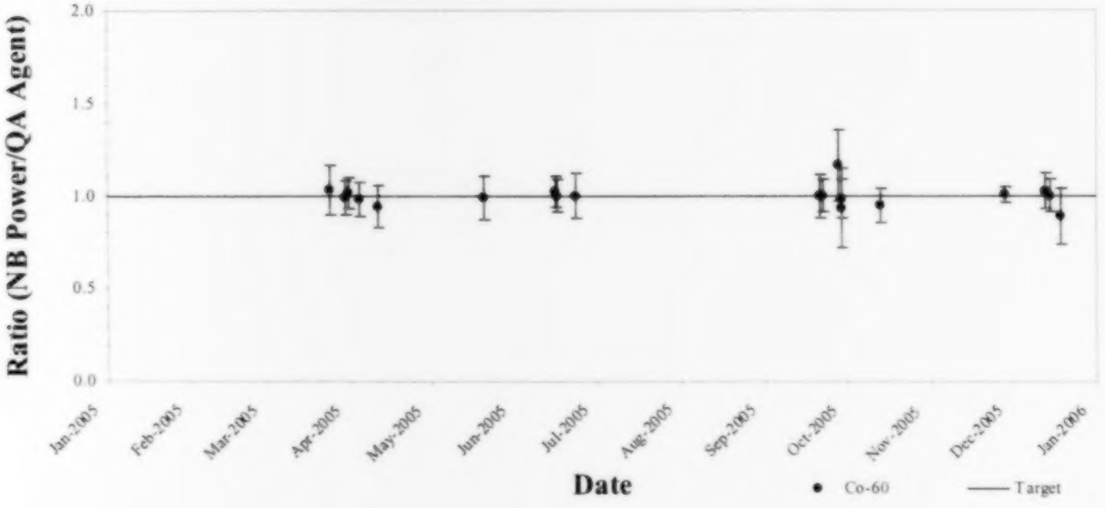

Figure 7.08: Cobalt-60 Performance (External QA)

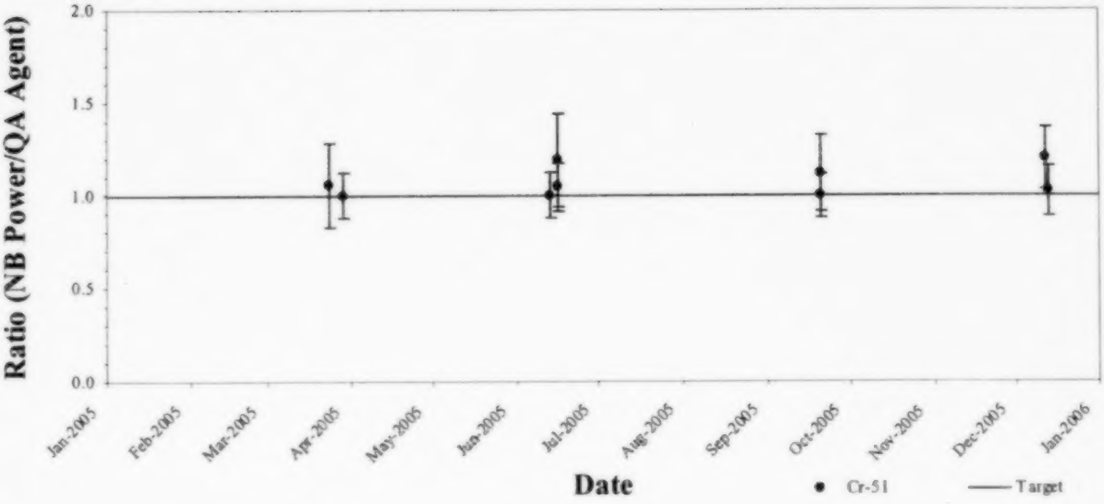

Figure 7.09: Chromium-51 Performance (External QA)

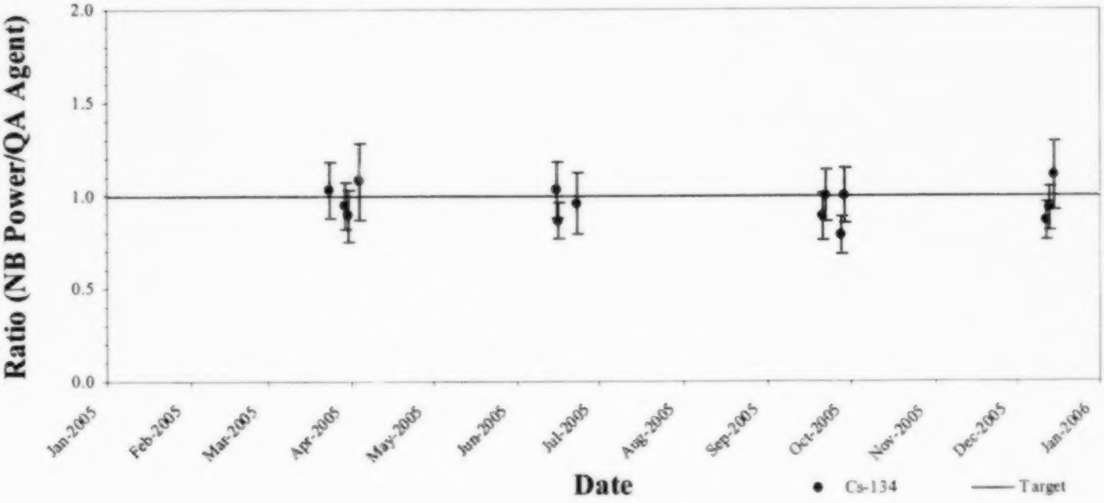

Figure 7.10: Cesium-134 Performance (External QA)

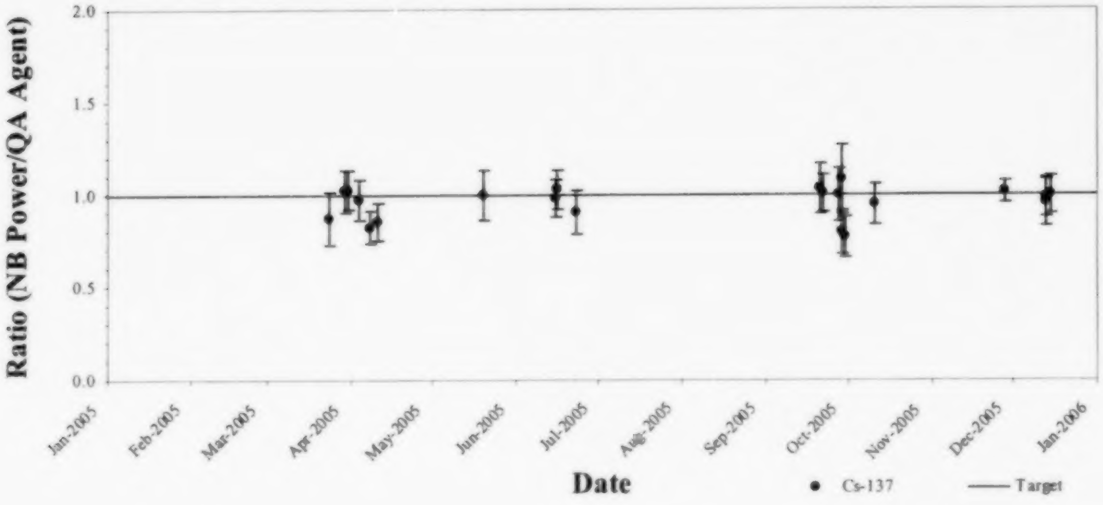

Figure 7.11: Cesium-137 Performance (External QA)

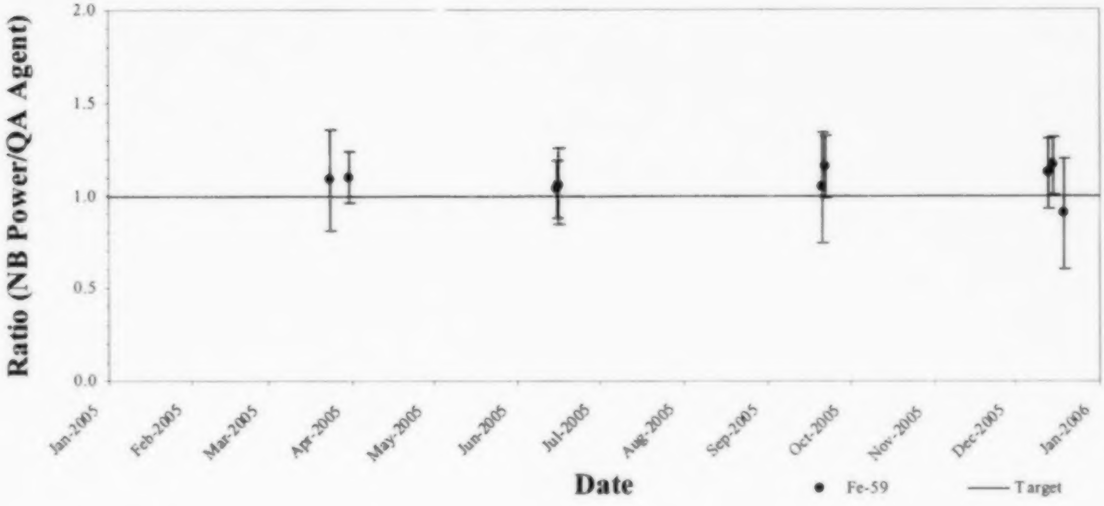

Figure 7.12: Iron-59 Performance (External QA)

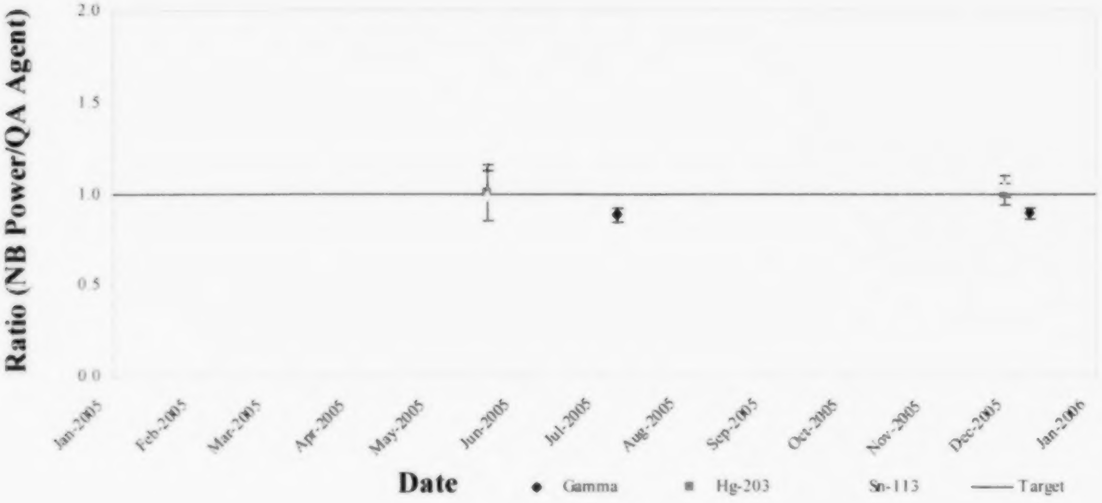

Figure 7.13: Gamma, Hg-203 and Sn-113 Performance (External QA)

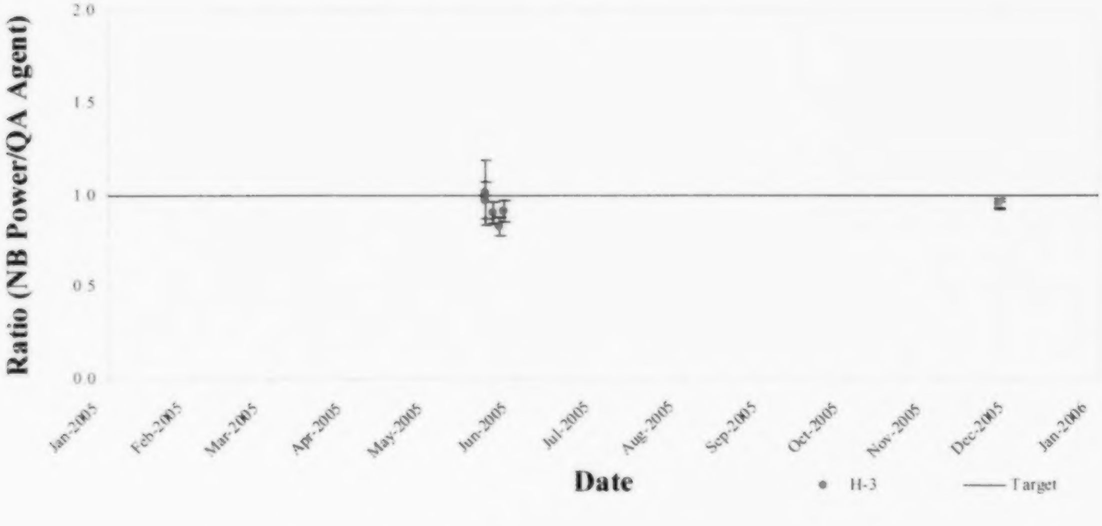

Figure 7.14: Tritium Performance (External QA)

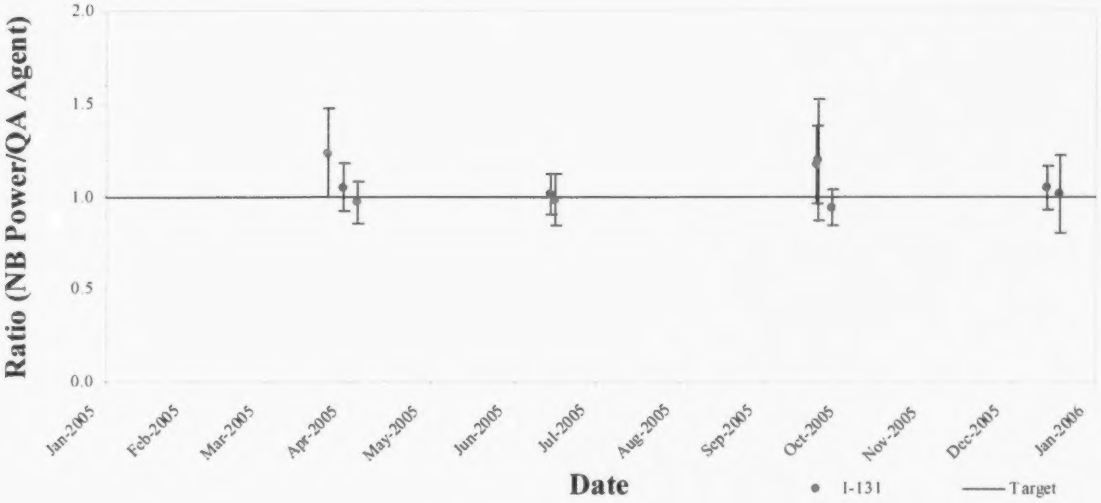

Figure 7.15: Iodine-131 Performance (External QA)

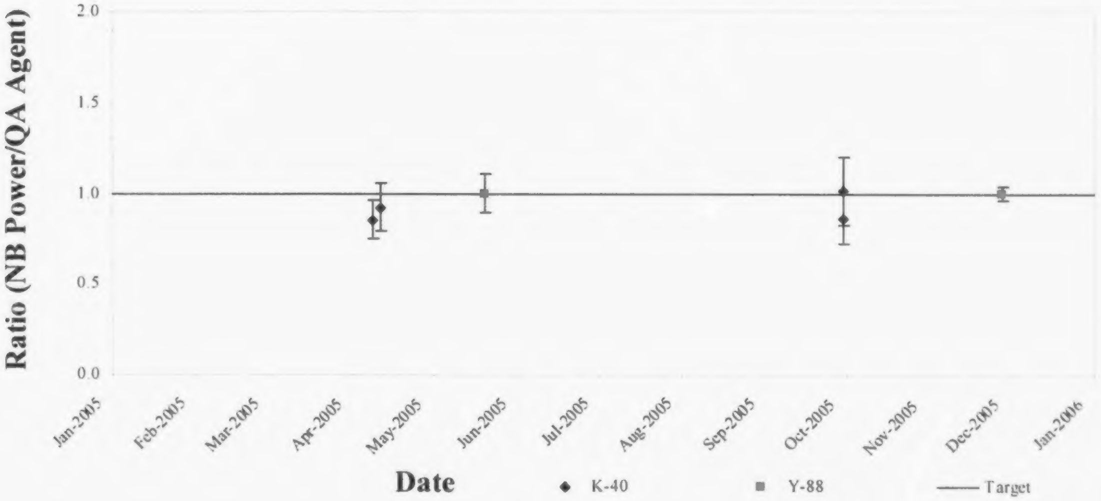

Figure 7.16: Potassium-40 and Y-88 Performance (External QA)

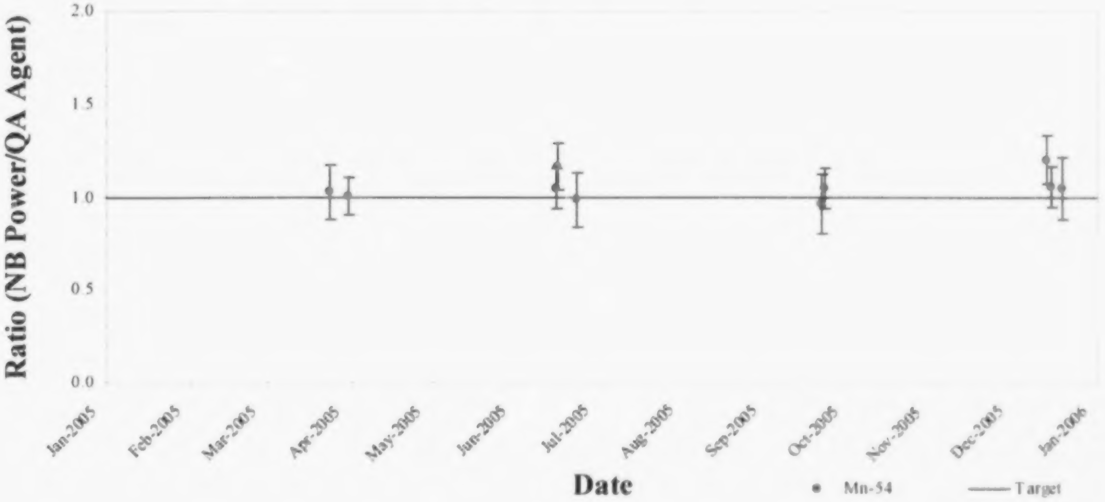

Figure 7.17: Manganese-54 Performance (External QA)

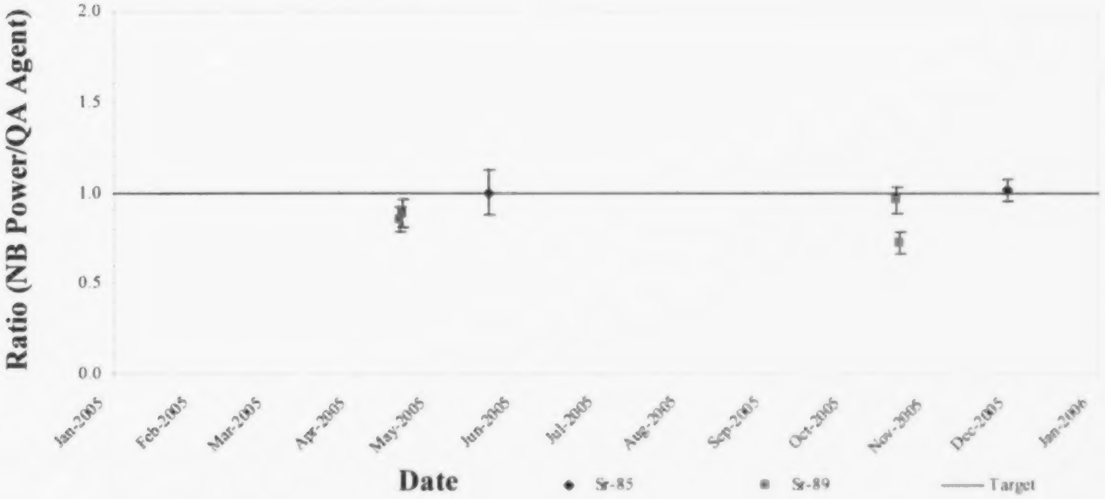

Figure 7.18: Strontium-85 and Sr-89 Performance (External QA)

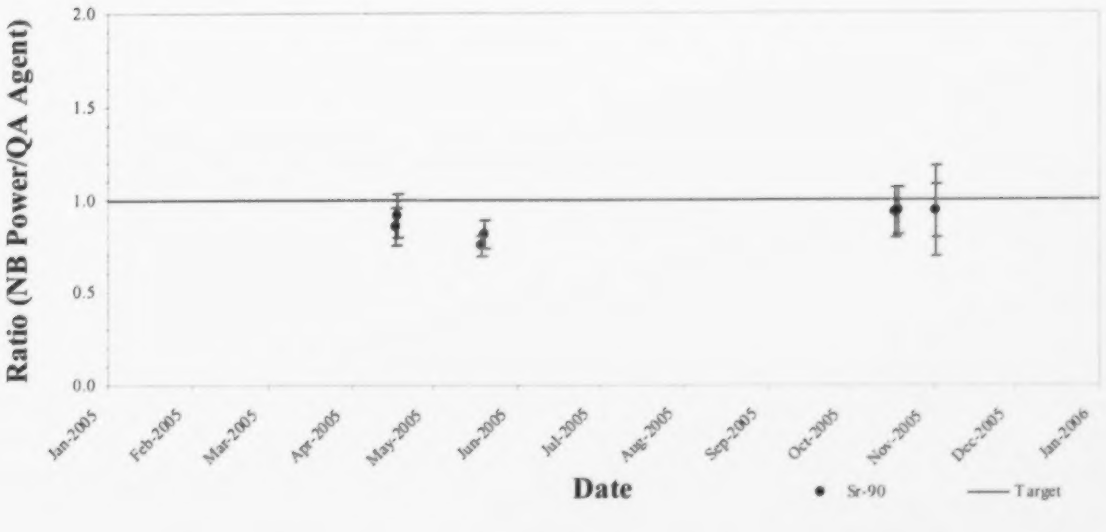

Figure 7.19: Strontium-90 Performance (External QA)

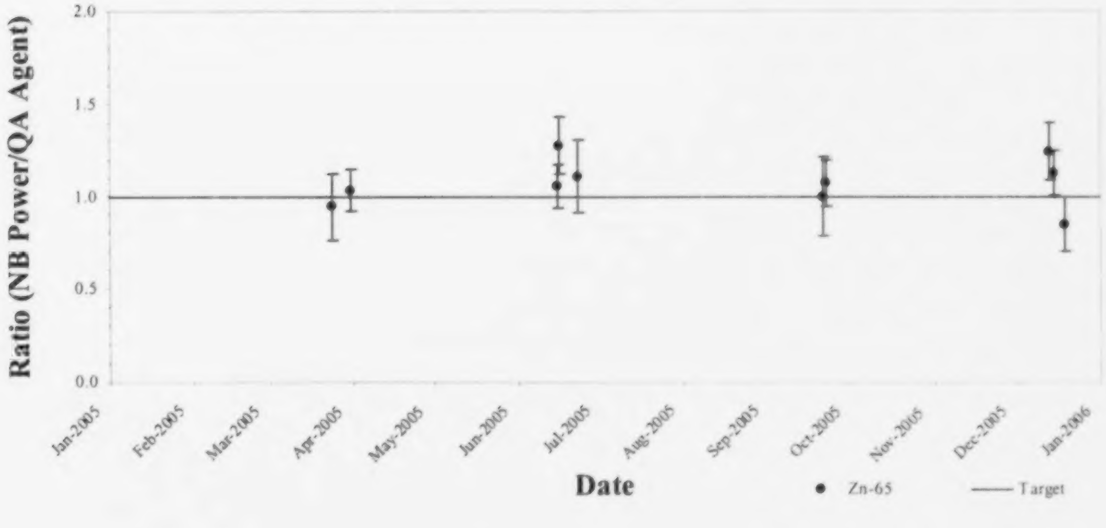

Figure 7.20: Zinc-65 Performance (External QA)

7.03 Internal QA

There are four parts to Internal QA:

1) duplicate samples – two samples collected at the same time and analysed separately
2) replicate analyses – two analyses done on the same sample
3) spiked samples – one person spikes a sample and a different person performs the analysis
4) repeated analyses of calibration standards or stock solutions

Duplicate samples and replicate analyses are employed as part of the overall quality assurance program. For those media where two samples can be obtained from the same location at the same time, similar analytical results are expected. This approach demonstrates that the samples are representative of the medium in that area. Where duplicate samples are not possible, e.g., air filters, a sample is counted twice to demonstrate reproducibility in the counting system. Tracking of results is done in a spreadsheet and performance is charted. If the range of the ratio (of the two detected measurements) plus or minus the combined uncertainty (95% confidence interval) includes 1.00, then performance is acceptable. See Table 7.12 for the frequency.

There were 197 radionuclide comparisons performed on 90 samples analysed. Sixteen of these had failures in one of the comparisons:

- Gross Beta in LEM Composite – There were four failures due to the statistics associated with the comparisons of low activities.
- Gd-153 in LEM Composite – There was one failure due to the statistics associated with the comparisons of low activities.
- Be-7 in Charcoal Cartridge – There was one failure due to the statistics associated with the comparisons of low activities.
- Cs-137 in Soil – There was one failure due to a difference in the duplicate sample.
- K-40 in Soil – There were two failures due to differences in the duplicate samples.
- H-3 in Parshall Flume Water – There were six failures. Four of them were within ten percent of their matched comparison, but failed due to tight counting statistics. There were four failures due to the statistics associated with the comparisons of low activities.
- Gross Alpha on Air Filter – There was one failure due to the statistics associated with the comparisons of low activities.

The results are presented graphically in Figures 7.21 to 7.33 (plotted against the analysis date).

Table 7.12: Internal Quality Assurance Frequency

Medium	*Duplicate/Replicate*	*Number of Radionuclide Comparisons*	*Analyses*
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodines	Replicate count (1 composite set)	34	Gamma
Airborne Particulates	Replicate analysis	12	Gamma
		24	Alpha/Beta
Garden Vegetables	Replicate analysis	9	Gamma
Milk	Duplicate sample	8	Gamma
Parshall Flume	Replicate analysis	12	LSC H-3
LEM Composite	Replicate analysis	35	Gamma
		22	Alpha/Beta
		10	Sr-89,90
Sea Food	Replicate analysis	1	Gamma
Sediment / Soil	Duplicate sample	15	Gamma
Environmental Gamma	Duplicate sample	3	TLD

Table 7.12: Internal Quality Assurance Frequency

Medium	*Duplicate/Replicate*	*Number of Radionuclide Comparisons*	*Analyses*
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodines	Replicate count (1 composite set)	34	Gamma
Airborne Particulates	Replicate analysis	12	Gamma
		24	Alpha/Beta
Garden Vegetables	Replicate analysis	9	Gamma
Milk	Duplicate sample	8	Gamma
Parshall Flume	Replicate analysis	12	LSC H-3
LEM Composite	Replicate analysis	35	Gamma
		22	Alpha/Beta
		10	Sr-89,90
Sea Food	Replicate analysis	1	Gamma
Sediment / Soil	Duplicate sample	15	Gamma
Environmental Gamma	Duplicate sample	3	TLD

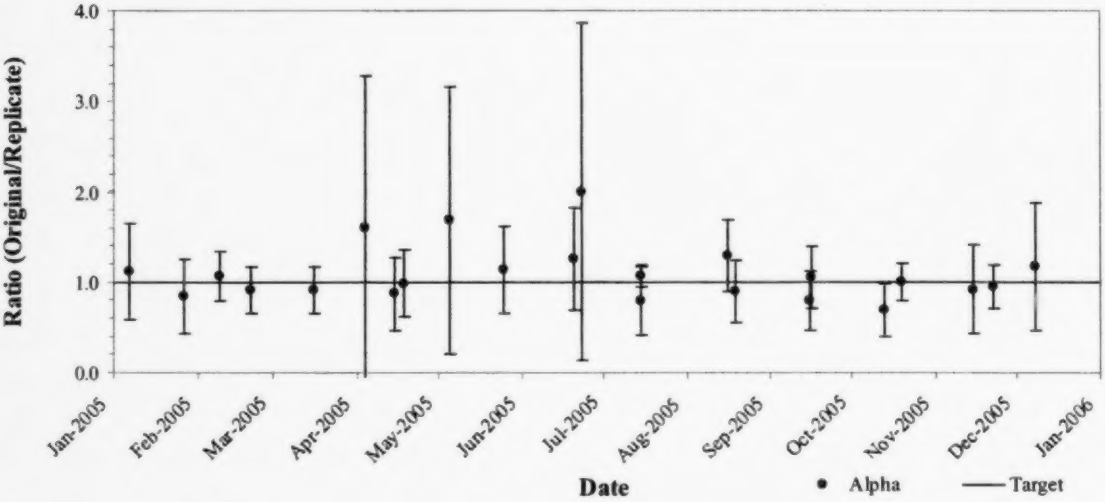

Figure 7.21: Alpha Performance (Internal QA)

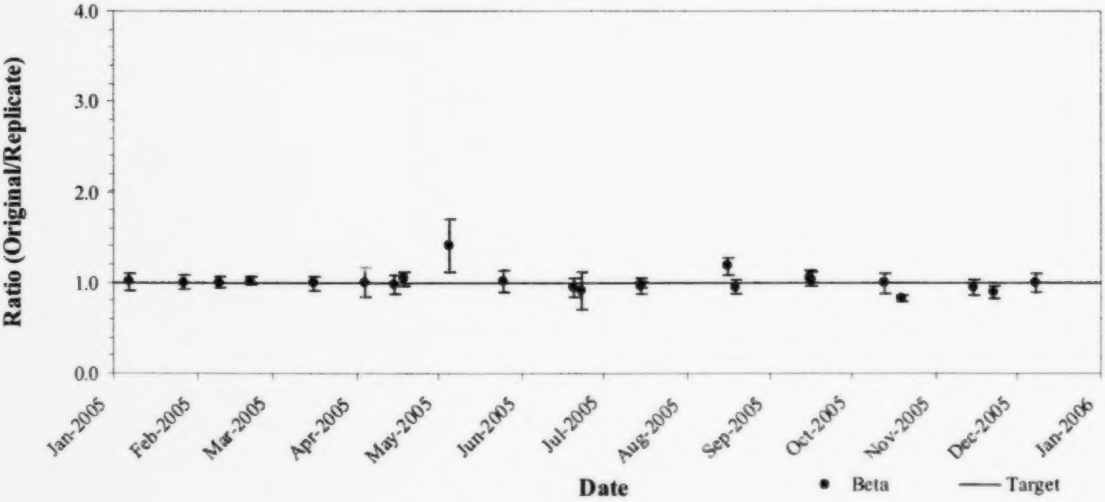

Figure 7.22: Beta Performance (Internal QA)

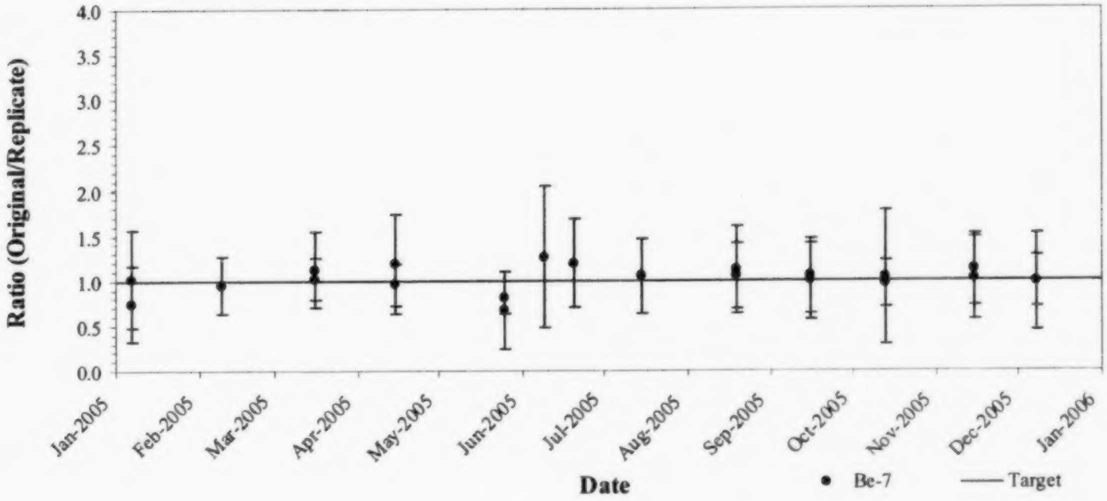

Figure 7.23: Beryllium-7 Performance (Internal QA)

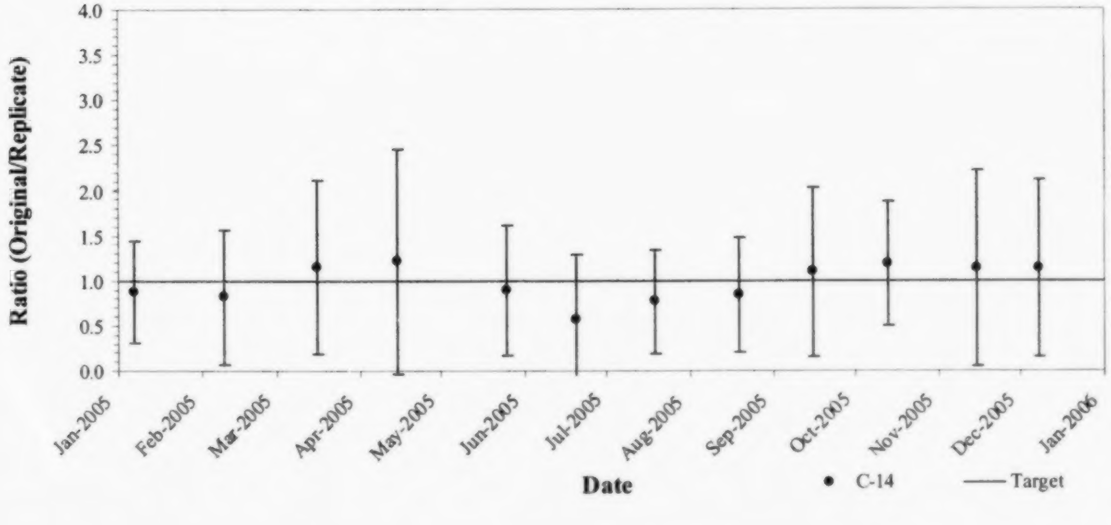

Figure 7.24: Carbon-14 Performance (Internal QA)

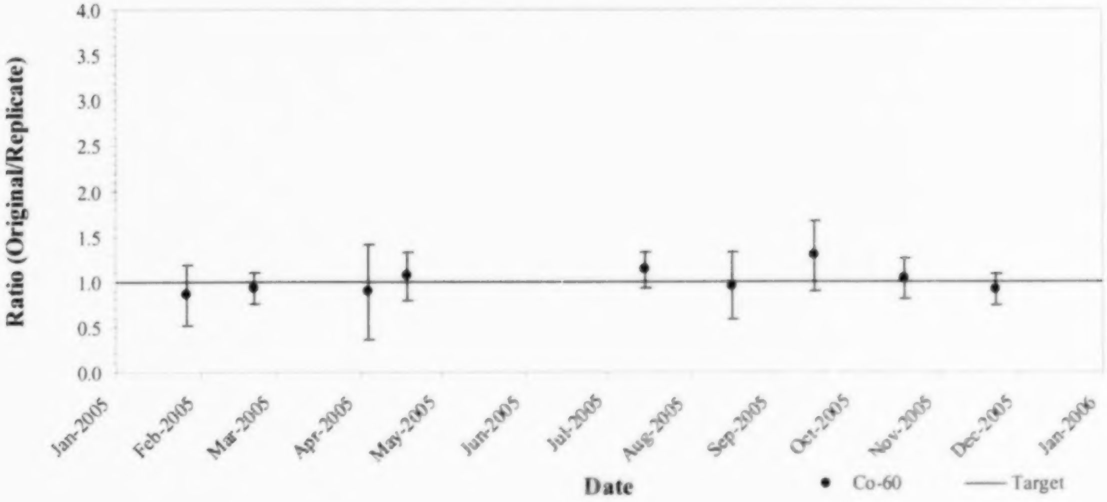

Figure 7.25:   Cobalt-60 Performance (Internal QA)

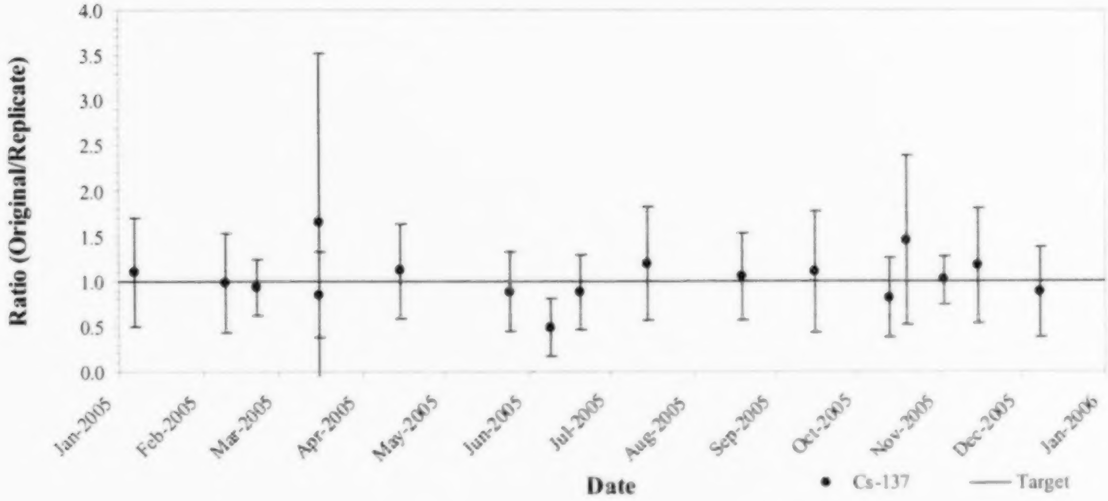

Figure 7.26:   Cesium-137 Performance (Internal QA)

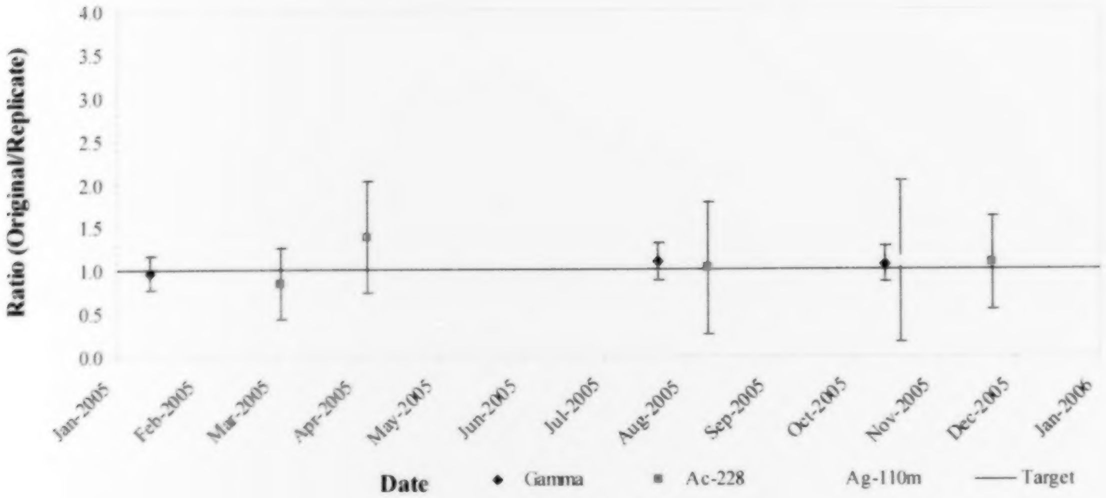

Figure 7.27: Gamma, Ac-228 and Ag-110m Performance (Internal QA)

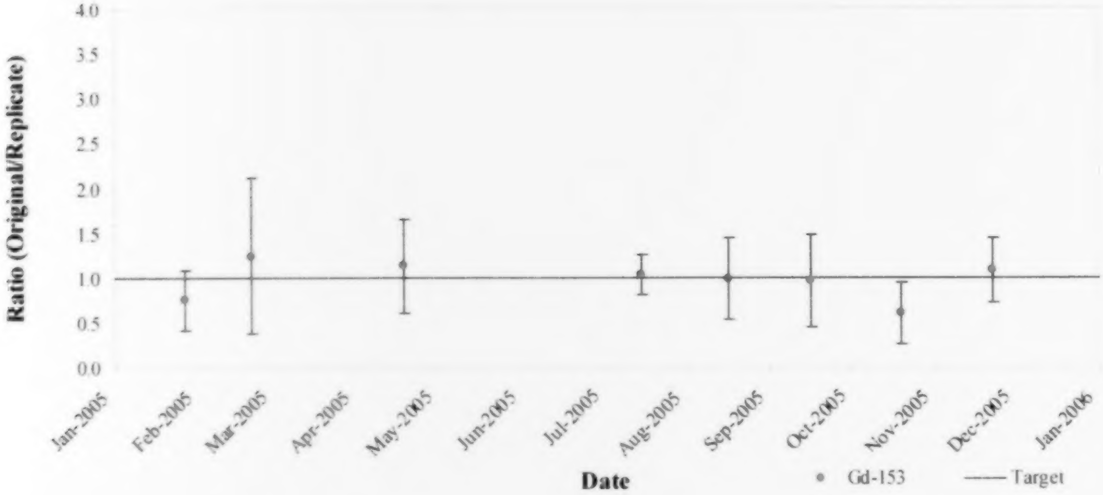

Figure 7.28: Gadolinium-153 Performance (Internal QA)

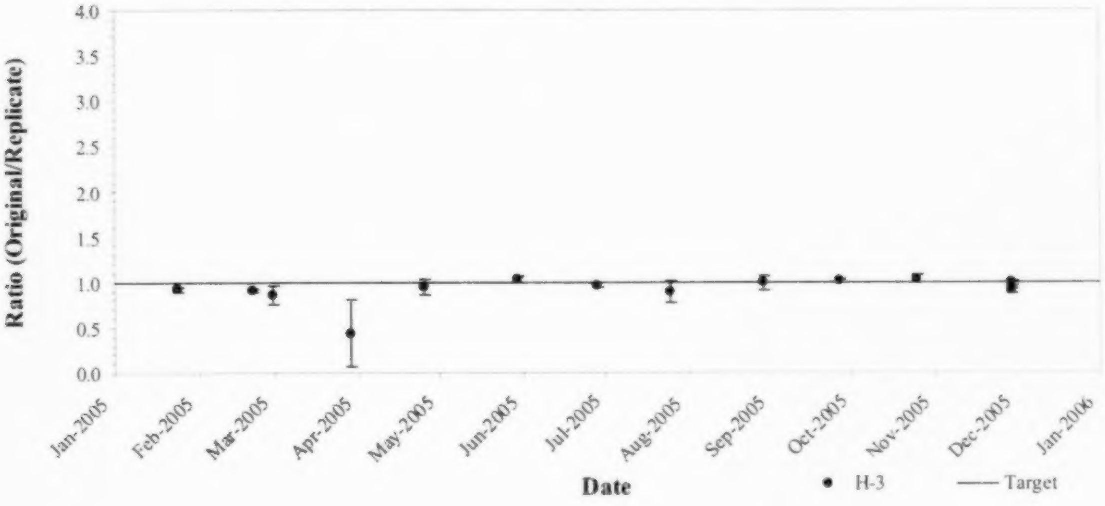

Figure 7.29: Tritium Performance (Internal QA)

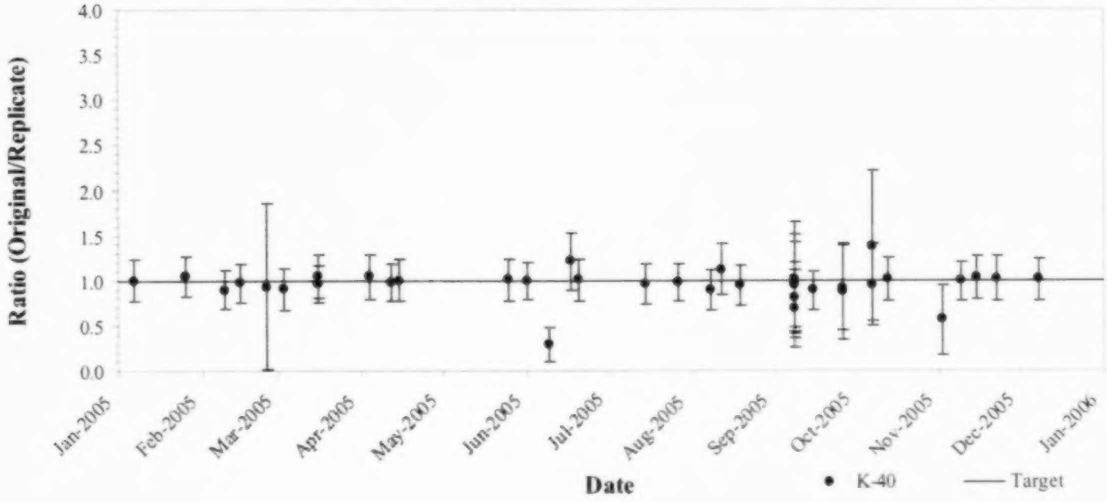

Figure 7.30: Potassium-40 Performance (Internal QA)

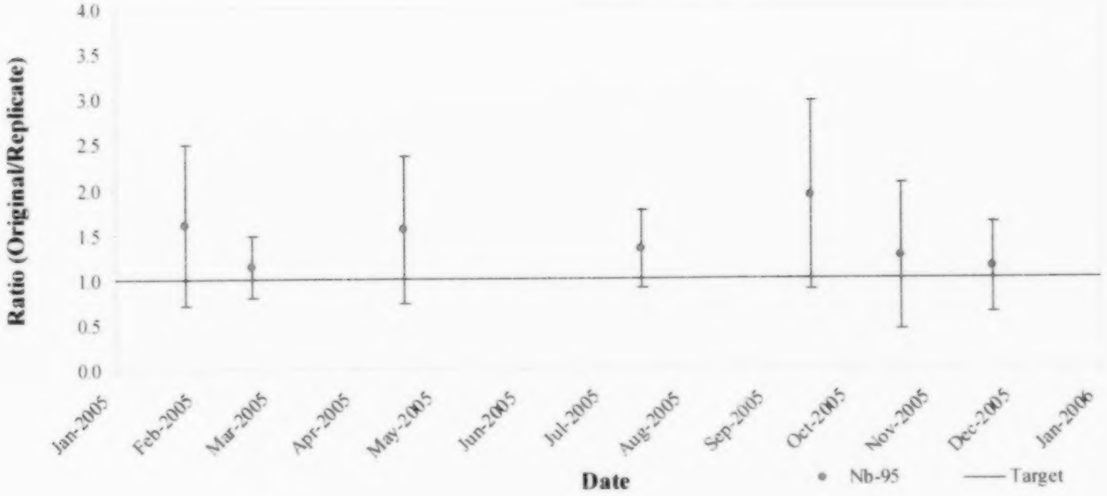

Figure 7.31: Niobium-95 Performance (Internal QA)

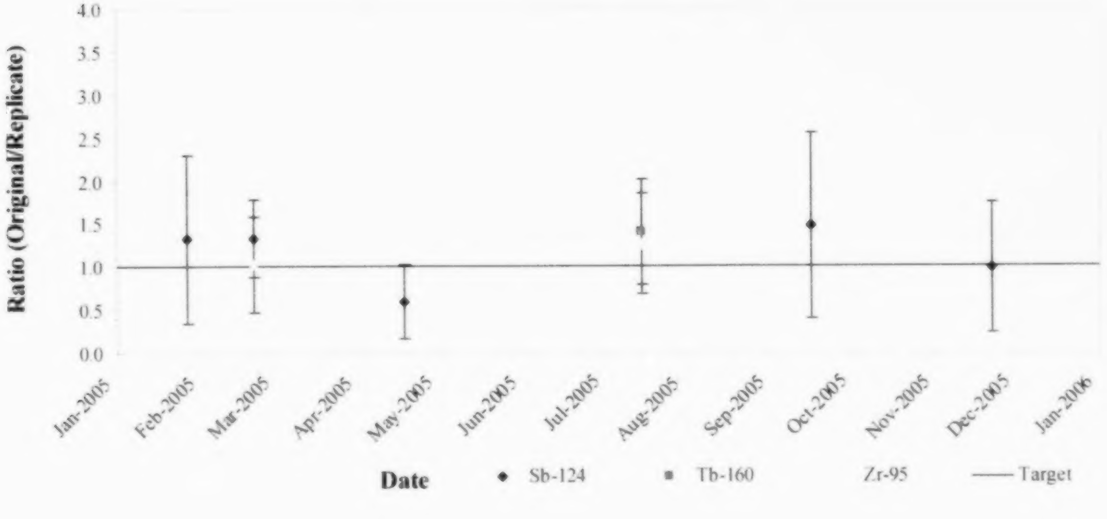

Figure 7.32: Antimony-124, Tb-160 and Zr-95 Performance (Internal QA)

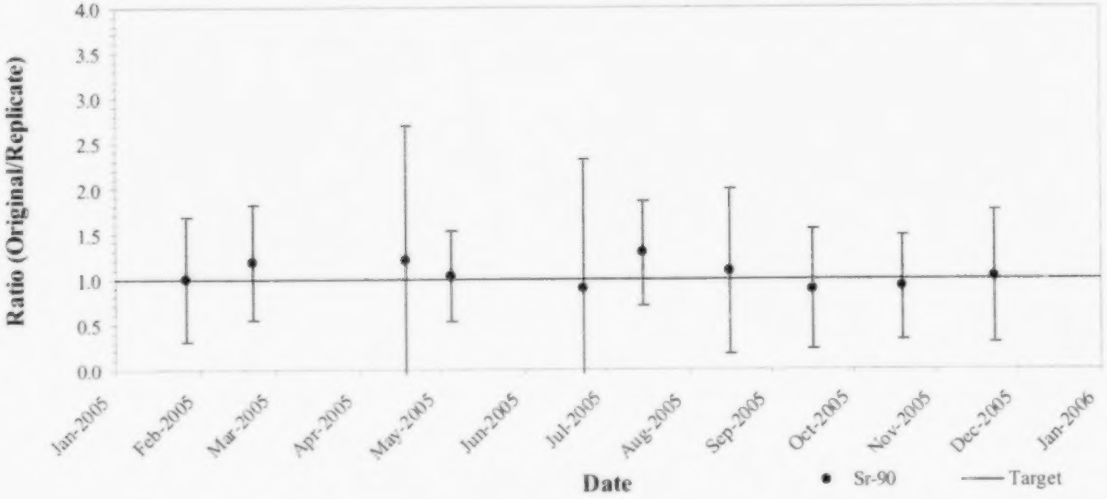

Figure 7.33: Strontium-90 Performance (Internal QA)

Samples that are spiked by laboratory personnel play a minor role in the QA program. It is more desirable to purchase QA samples from an accredited QA laboratory. The only exception is the irradiation of environmental TLDs. Similar to External QA, one member of the lab staff irradiates the TLDs and a different person analyses the sample. Results of performance with these samples give an indication of the quality of measurements. Acceptable performance is defined as results within ± 10% of the expected value.

There were no failures in the four separate tests (five TLDs for each test). The results are presented in Figure 7.34

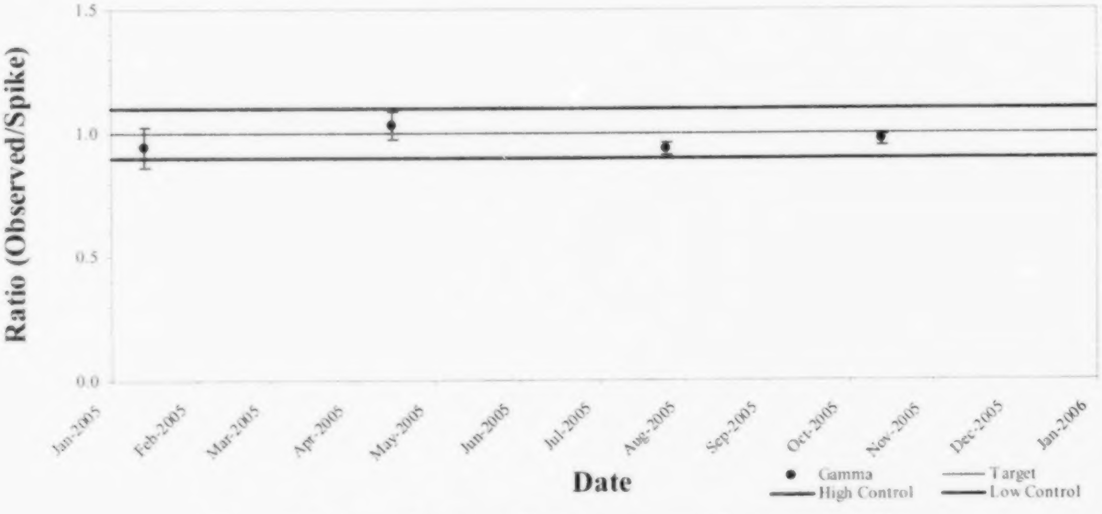

Figure 7.34: Gamma Performance (Internal QA)

As well, stock solutions of C-14 and H-3 and were repeatedly analysed throughout the year. The results are shown in Figures 7.35 and 7.36. These practices provide an extra degree of confidence in the Environmental Program. Acceptable performance is defined as results within ± 10% of the expected value. There were eight individual radionuclide failures (six for C-14 and two for H-3) out of 76 tests.

The poor performance of the C-14 is due to the age of the stock solution. A positive bias is observed in the C-14 stock solution due to evaporation over many years. This standard has been replaced.

A slightly negative bias is observed in the H-3 stock solution. This is due to the two to three percent difference between chemical quench and opacity quench.

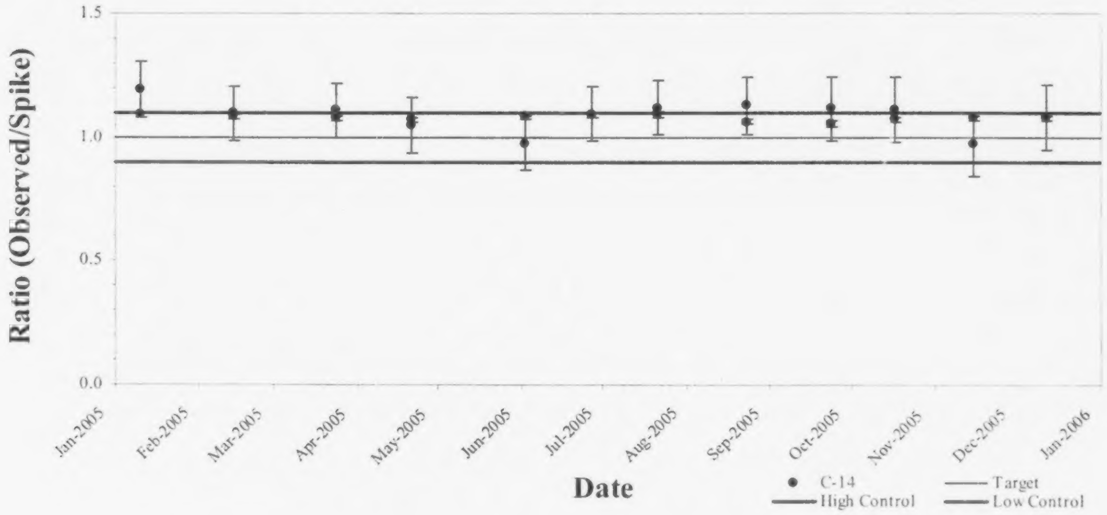

Figure 7.35: Carbon-14 Performance (Internal QA)

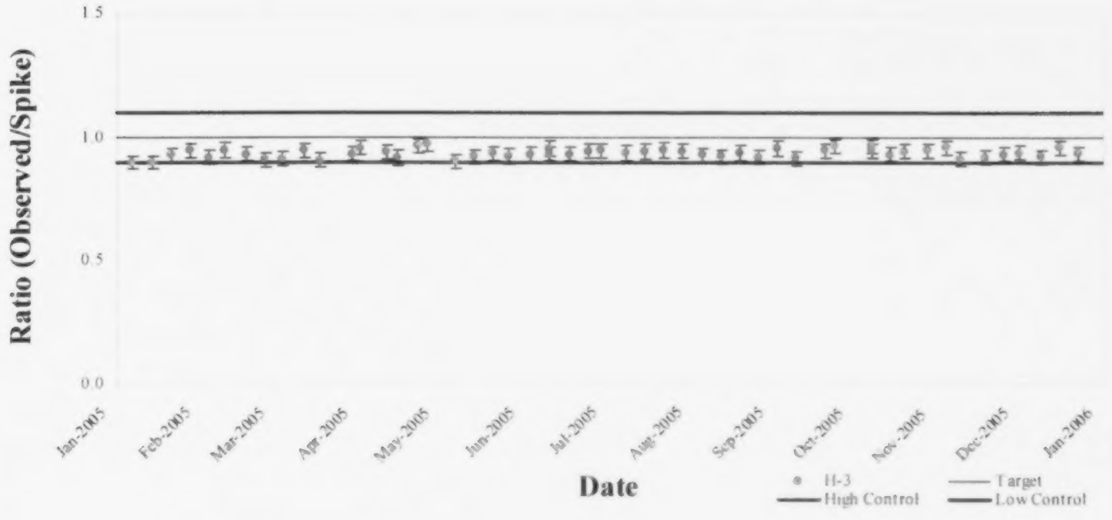

Figure 7.36: Tritium Performance (Internal QA)

The laboratory also analysed samples for several commercial clients. A calibration standard was run with each set of samples to indicate the reliability of the results to the customer. There were five individual radionuclide failures out of 120 tests. These were marginal failures. The results and analysis dates are presented in Figures 7.37 to 7.38.

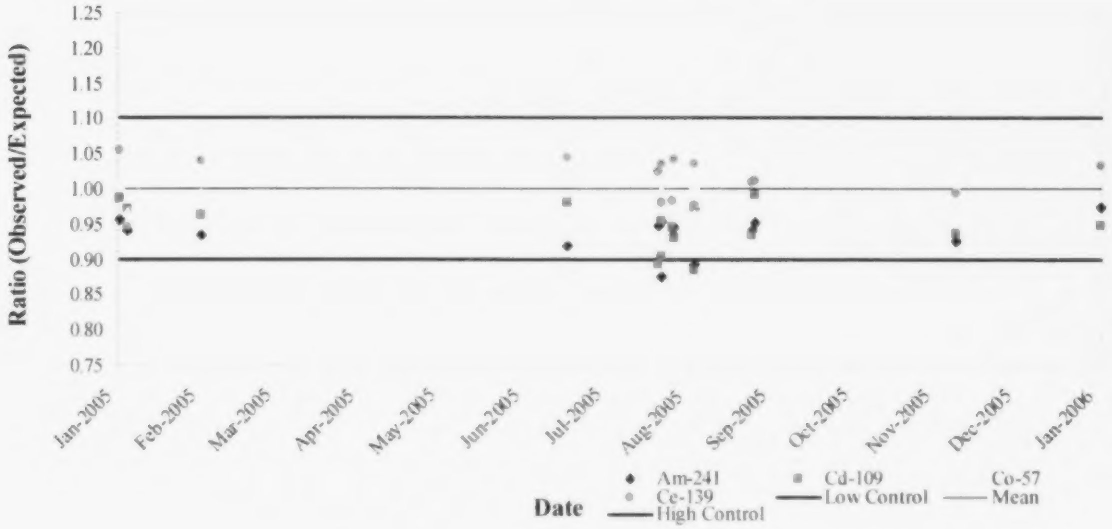

Figure 7.37: Americium-241, Cd-109, Co-57 and Ce-139 Performance (Internal QA)

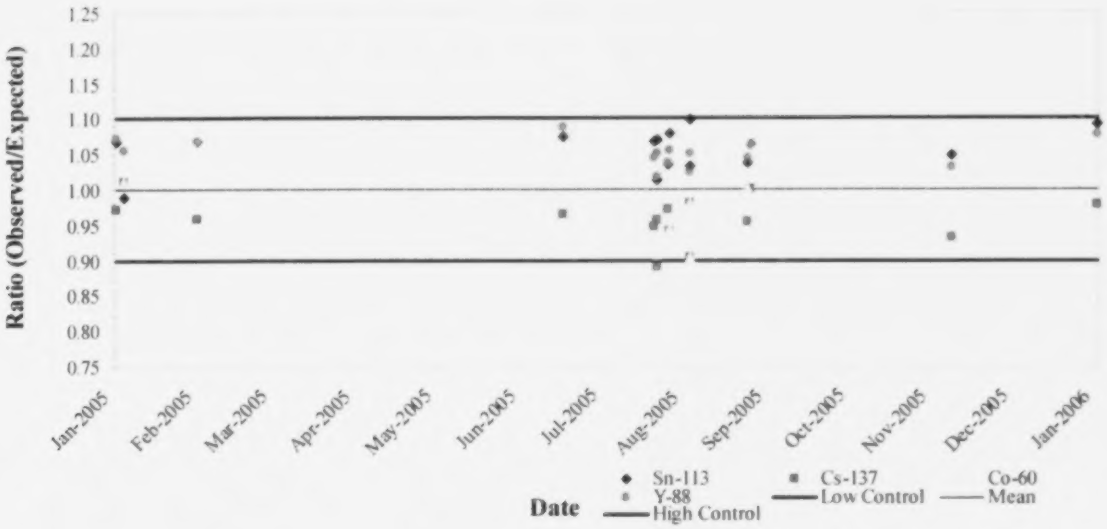

Figure 7.38: Tin-113, Cs-137, Co-60 and Y-88 Performance (Internal QA)

7.04 Program Audit

The OERMP audit frequency was changed to once every five years to align with the Canadian Standards Association (CSA) standard. The Independent Assessment Group at PLGS is the principal auditor, although other groups from within NB Power, the CNSC, or other utilities may be used. The last audit was in 2004 and is due again in 2009.

As part of its overall Management System, Point Lepreau has an Environmental Management System (EMS) in place that is registered to ISO 14001. Radiological releases to water and air are part of this system. There were environmental audits relating to the EMS during the year, although the OERMP was not specifically examined.

7.05 Annual Review

A major review of the Operational Environmental Radiation Monitoring Program (OERMP) takes place each year. The requirement for this review is stated in the Reference Document (Operational Environmental Radiation Monitoring Program(9)) and described in the Procedure Document (Environmental Radiation Monitoring Program Procedures(13)). All members of the lab take part in this formal review. Generally, all aspects of the program are examined to make sure that the objectives, as stated in the Reference Document, are being met.

The following are the major items from the review:

- objectives of the program were met.

- increasing concentration of tritium in Parshall Flume water from the Solid Radioactive Waste Management Facility (SRWMF) Phase 1. It is still below the peak concentration observed in 2000.
- continued low dose to members of the Critical Groups due to continued low emissions since 1995.
- continued low concentration of tritium in water vapour (onsite locations) since 1994.
- decreasing concentration of tritium in monitoring wells (near plant) since 2001.
- continuing detection of tritium in air and water samples (higher onsite than offsite).
- continuing difference between onsite and offsite thermoluminescent dosimeter (TLD) measurements.
- decreasing TLD measurements with distance from the SRWMF Phase 2 fence.
- work on new DELs continued.
- a review of current analytical methods and practices identified several improvements that will be made to existing procedures

7.05.01 Routine Monitoring Results

The analyses results are examined for consistency and trends using graphs and tables created for the Annual Report and using the performance indicators described in the Procedures. Any unusual results and problems are also examined.

This aspect of the review is discussed in sections 4 and 5 of this report.

7.05.02 Procedures

The adequacy and accuracy of field and laboratory procedures are evaluated. New or replacement methods are examined and obsolete ones are deleted. Procedures are completely revised every five years and their execution by staff is regularly checked. Any deviations from these procedures are to be documented in the Annual Report.

Procedures were revised and issued early in 2004. These will be reformatted in 2006 to meet the requirements of the new documentation process at PLGS.

Procedures are required to address analyses that may be required if greater than 1% DEL is released from PLGS.

In light of a review (March, 2006) of current analytical methods and practices, several improvements will be made to existing procedures in 2006.

The switch over to GENIE 2000 gamma spectroscopy software in 2006 will require some procedural changes.

7.05.03 Analytical QA Results

Failures and biases associated with the Analytical QA Program and the Daily QC Checks are addressed. Graphs and tables produced for the Annual Report as well as the QC Failure Log Book are used. Schedules, number of samples and problems are addressed. The degree of satisfaction with external agencies and options for different suppliers of these samples are explored.

This aspect of the review is discussed in Sections 7.01 to 7.03 of this report.

A new C-14 standard was purchased and the stock solution will be replaced to improve C-14 QA performance.

The quality of reporting by one of the QA providers needs to be addressed.

7.05.04 Equipment

The status of laboratory and field equipment, software and facilities are considered.

A positive refurbishment decision for PLGS was announced in 2005. All equipment, software and facilities were examined in light of the planned extension in operation of the program

Laboratory – All equipment is in good shape. New DSA boxes (gamma spectroscopy system) have been purchased by the department. These will be commissioned in 2006. As well the TLD reader was refurbished in 2005. A new set of calibration weights was purchased.

Software – Plans for an upgrade to the Genie 2000 gamma spectroscopy system are progressing, as is the changeover from the current Alpha based computer system to an NT box. Spreadsheet versions of the analytical software have been developed as an emergency backup and as a tool to verify software changes

Field – Supply of air meters is a problem.

7.05.05 Personnel

Training during the previous year is reviewed and plans for the coming year are made from the point of view of program requirements and employee development. Human resources available to accomplish program objectives are evaluated.

The following training (relevant to the program) was received by laboratory personnel:

- *Transportation of Dangerous Goods*
- *Radiation Biology & Radiological Risk Workshop*
- *Chart of the Nuclides*

- *24th Annual International Dosimetry Symposium and National Dosimetry Records Conference*
- *Radiation Protection Training Refresher*

7.05.06 Safety

Laboratory and field work safety is reviewed.

There were no outstanding safety issues. The laboratory holds quarterly loss control meetings.

7.05.07 Emissions

The final gaseous and liquid effluent reports are studied. Their impact on routine monitoring results and their implications to the OERMP are assessed.

There were no unusual emissions that warranted any change to the program. Work on a major revision to the DELs continued as a co-operative undertaking with all COG members.

7.05.08 Meteorological Data

The impact of meteorological data on routine monitoring results and the implications to the OERMP are assessed. The results of the Meteorological Monitoring QA analysis are discussed.

The plant logging system is now the source of the MET data used in this report.

7.05.09 Emergency Measures Organization Demographic Data

When available, these data are studied for implications to the program.

No survey took place in 2005.

7.05.10 Appropriateness of Media, Locations and Frequency

The choice of media, and location and frequency of sampling are examined in the broader context of the past year. Possible adjustments are examined to reflect changing conditions in the Lepreau area and future plans and expectations for PLGS from the public and CNSC.

Two drafts of environmental Guidance Documents (CNSC) were released in 2004 along with the associated Standards. Action plans will be developed when the final reports are issued.

7.05.11 High LLDs

The summary report of dose to the Critical Group at the LLD is studied.

The major radionuclides that exceed the 5 μSv level (annual average) continue to be noble gases These are detected with a TLD which measures 20 μSv dose. However the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are:

- Ba-140 in soil (7.6 μSv); sediment (7.7 μSv)
- Ce-144 in pond/puddle/surface water (10.6 μSv); precipitation (10.1 μSv); well water (10.5 μSv); garden vegetables (5.0 μSv)
- Ru-106 in pond/puddle/surface water (15.3 μSv); precipitation (12.6 μSv); well water (10.2 μSv); garden vegetables (12.0 μSv); berries (8.5 μSv); clams (8.4 μSv)
- I-131 in garden vegetables (8.2 μSv)

Effluent analyses show these are not a major component of emissions and no changes to counting protocols are warranted.

7.05.12 Records

The completeness and consistency of data in the environmental records database are verified at the end of each monitoring year. A QA audit is also performed on the paper copies of analysis reports filed in the laboratory office. The changes to the database are documented.

- There were six changes made to the database. Most of these were due to operator error.

7.05.13 Contamination

Results from routine contamination monitoring as well as equipment background checks are examined.

There were no contamination issues in 2005.

7.05.14 Problem Resolution

The PICA system at PLGS was implemented to identify, track and trend conditions, concerns, and problems and solutions.

The few entries made were for External QA failures and accessibility issues associated with TLD collection.

7.05.15 Changes to Reference Document

Major changes since the last review are documented for the annual report.

The latest revision of the OERMP Reference Document was issued in January, 2000. A new revision is planned for one year after the four CNSC Guidance Documents are issued. Major changes to the current revision are:

Changes During 2000

- gross alpha/beta counting is not done on seawater or milk samples
- Sr-89,90 analysis is performed on air filters if more than 1% DEL (GEM) is released from PLGS
- Sr-89,90 analysis is performed on seawater if more than 1% DEL (LEM) is released from PLGS
- soil is not sieved and not always heated before counting
- procedures are checked at least every three years as are their execution by staff
- I-131 is not included in any QA samples
- Sr-89,90 and Cs-137 are not included in Duplicate/Replicate filter samples
- Sr-89 is not included in most QA samples
- the major review of the program takes place in February and is approved in March
- I00G (now I11G) is on the north fence (west side)
- I00I (now I11I) is on the north fence (east side)
- gross alpha/beta counting is done routinely on well water samples, but only on other water samples if they contain significant gamma activity
- three DELs were changed to match CNSC limits (Kr-85, I-131 and I-133)

Changes During 2001

- TLDs are no longer placed at B9, B10, I90-I95, I98 & I99
- well water is no longer collected at N03
- a new aquaculture salmon site has been added close to PLGS
- soil and gamma surveys were suspended at Hemlock Knoll
- 18 new bore holes and monitoring wells were added

Changes During 2002:

- an increase in the number of external QA samples replaced a decrease in the number of internal spikes
- a new groundwater sampling procedure was implemented
- All activities that support PLGS will be controlled by the PLGS Management System that is under development. The environmental monitoring program falls under the primary process *SU-2 Provide Environmental Services*. This process was mapped, and all sub-processes related to routine environmental monitoring come under it.
- clam location at Dipper Harbour (N04) deleted

Changes During 2003:

- reduced the frequency of monitoring well sampling from three times per year to once per year (obtained CNSC approval)

- C-14 analysis is performed on milk, water, berries, and garden vegetables if more than 1% DEL (GEM) is released from PLGS
- C-14 analysis is performed on seawater and seafood if more than 1% DEL (LEM) is released from PLGS
- H-3 analysis is performed on berries and garden vegetables if more than 1% DEL (GEM) is released from PLGS
- H-3 analysis is performed on seafood if more than 1% DEL (LEM) is released from PLGS
- reduced the number of QA samples (a new schedule)
- changed the audit frequency to once every five years to align with the CSA standard

There were no changes in 2004.

Changes During 2005:

- TLDs are no longer placed at A6, A7, A8, A9 and YTL5

Planned Changes for 2006:

- reduce the frequency of bore hole sampling from three times per year to once per year (pending CNSC approval)

7.05.16 Program Audit

The results of any audits are reviewed.

This aspect of the review is discussed in Sections 7.04 of this report.

7.05.17 Program Improvement

Areas for improvement are identified:

- *from relevant operating experience (internal & external) (EN-418)*
- *during the annual review (EN-414)*
- *during audits*
- *by laboratory staff*
- *by other HP staff*
- *by the Manager, Personnel Safety and Environment*
- *by the self assessment process*

Deficiencies in any of the listed areas are dealt with promptly. The results of the Annual Review are used to improve the program, and are included in the Annual Report.

The preceding sections describe ways that the program will be improved in 2005.

8 Reports and Studies

Work that began in 2002, and that continued into 2005, includes the next revision of the DELs and the farming of the data collected from the NaI monitoring network by Health Canada.

COG released several Reports and Technical Notes that contained interim data from current research projects, guidance for future program development and plans for future projects near PLGS.

Appendices

Appendix A: Statistics, Detection Limits, and Dose at Detection Limits

A1 Statistics

The following statistical conventions are applied in the analysis of each sample:

- Detection limits are defined following the method described by Lochamy[(15)]. The lower limit of detection (LLD) at the 99% confidence level is defined as 6.58 S_b, where S_b is the standard deviation of the appropriate radiation background measurement. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than 3.29 S_b, or the so-called critical level (CL), with 99% probability. Thus, the LLD specifies the theoretical capability of the system to detect a given amount of radioactivity, whereas the CL is used to determine whether an actual activity measurement should be considered detected. Any net measurement greater than 3.29 S_b is considered detected at the 99% confidence level. This also implies a 1% probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level (6.58 S_b), there is a 1% probability of stating that activity is not present when it is (false negative).

- The CL of 3.29 S_b and LLD of 6.58 S_b apply in those analytical systems where the background levels are either not well defined, or where there is a relationship between the background levels and the detected signal above background, as in Ge gamma spectroscopy. Where the background readings are well defined and are independent of sample readings, as in the TLD data, the CL is 2.33 S_b and the LLD is 4.66 S_b.

- In most of the tables of data (Section 4.0), it is this Critical Level that appears in column 2.

- Unless otherwise indicated, the precision of the measurements reported here is given as ± 1.96 S_a (95% confidence level), where S_a is the standard deviation of the activity measurement.

- The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as 3.2E-02.

The lower limits of detection (LLD) of all radionuclides in the various sample media are shown in Tables A.01 to A.11. The Annual Dose is to a member of the Critical Group. The LLDs are based on typical data. Decay of radionuclides is accounted for in the LLD calculations except for H-3 and C-14 (long half-lives). The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. Milk is assumed to be from a cow pastured at 1.5 km, fish and lobster are caught at the Condenser Cooling Water (CCW) outlet and sediment, dulse, seawater and clams are collected at Dipper Harbour.

The CSA recommends, where technically feasible, that all measurements achieve LLDs less than that which would result in a dose of 5 μSv to the Critical Group. Most radionuclides pass this criterion. The major exceptions are noble gases. Detection of this group is through TLD measurements (20 μSv dose to the Critical Group at the LLD). However, the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are Ba-140 in soil and sediment (10 to 12 μSv); Ru-106 in water and clams (7 to 17 μSv); Ce-144 in water (11 μSv); and I-131 in food (8 μSv). Effluent analyses show these are not major components of emissions. Part of the QA process identifies those LLDs or activities that do not meet this target.

A1.01 Air

A1.01.01 Airborne Particulates

Typical LLDs are given for a 2400 m^3 sample, counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection. Gross alpha/beta is for trending only.

A1.01.02 Airborne Radioiodines

A typical LLD for I-131 is approximately 9E-05 $Bq \cdot m^{-3}$ (for a 2400 m^3 sample, counted for 50 000 s), which is decay corrected to the midpoint between the start and end of sampling.

A1.01.03 Airborne Tritium

The LLD is approximately 1E-01 $Bq \cdot m^{-3}$ of air for a typical sample of 10 to 70 m^3 (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

A1.01.04 Airborne Carbon-14

A typical LLD is approximately 4E-02 $Bq \cdot m^{-3}$ of air for a 30 m^3 sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

A1.01.05 TLD

The LLD is about 20 μSv. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ± 10% at the 95% confidence level.

Table A.01 Annual Dose at the LLD for Air

Nuclide	*LLD (Bq·m^{-3})*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq·m^{-3})*
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	4.0E-02	1.9E+00	1.0E-01
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	8.4E-05	1.6E-01	2.5E-03
Xe-131m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03
Noble Gases	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Gross Alpha	6.6E-06		
Gross Beta	1.7E-05		

A1.02 Milk

The LLDs in Table A.02 apply to the midpoint between the start and end of sampling for a 3.6 L sample counted for 50,000 s for gamma and a 6 mL sampled counted for 100 min for tritium.

Table A.02 Annual Dose at the LLD for Milk

Nuclide	*LLD* $(Bq \cdot L^{-1})$	*Dose at LLD* (μSv)	*Activity That Gives 5* μSv $(Bq \cdot L^{-1})$
H-3	2.4E+01	3.1E-01	3.9E+02
Cr-51	6.4E-01	1.0E-02	3.1E+02
Mn-54	9.2E-02	1.9E-02	2.5E+01
Fe-59	2.2E-01	2.2E-01	5.1E+00
Co-58	9.0E-02	7.5E-02	6.0E+00
Co-60	1.1E-01	9.0E-01	6.1E-01
Zn-65	2.4E-01	5.3E-01	2.3E+00
Zr-95	1.6E-01	4.3E-02	1.8E+01
Nb-95	9.2E-02	1.2E-01	3.8E+00
Ru-103	8.4E-02	1.9E-02	2.2E+01
Ru-106	7.8E-01	2.7E+00	1.4E+00
Ag-110m	8.2E-02	5.5E-02	7.4E+00
I-131	9.4E-02	1.8E+00	2.6E-01
Cs-134	7.8E-02	3.1E-01	1.3E+00
Cs-137	9.8E-02	3.1E-01	1.6E+00
Ba-140	3.4E-01	2.1E-01	8.1E+00
La-140	1.1E-01	8.9E-02	6.1E+00
Ce-141	1.2E-01	3.0E-02	2.1E+01
Ce-144	5.0E-01	9.5E-01	2.6E+00

A1.03 Water

The LLDs in Table A.03 apply to the midpoint between the start and end of sampling for a 3.6 L sample counted for 5000 s for gamma and a 6 mL sampled counted for 100 min for tritium. Alpha/beta results (a 100-500 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

The LLDs are based on typical data for precipitation water (the only water sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD calculations, well water and other water sample types will have lower LLDs than these. The major assumptions are that the sample is taken at one kilometre from the point of emissions, that the level is maintained for the year and the sample type is the major source of drinking water. Obviously, this is not the case but it gives a simple "worst case" that is easy to monitor and calculate.

Table A.03 Annual Dose at the LLD for Water

Nuclide	*LLD* $(Bq \cdot L^{-1})$	*Dose at LLD* (*µSv*)	*Activity That Gives 5 µSv* $(Bq \cdot L^{-1})$
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00
Gross Alpha	1.2E-01		
Gross Beta	8.4E-02		

A1.04 Food

The LLDs in Table A.04 apply to the time of sample collection. Samples vary in size and are counted for 5000 s. The LLDs are based on typical data for garden vegetables. Garden vegetables have significant radioactive decay before analysis as the local residents harvest and store them for varying lengths of time before collection. Since decay of radionuclides is taken into account in the LLD calculations, berries and other food sample types, which experience less radioactive decay, will have lower LLDs than these.

Table A.04 Annual Dose at the LLD for Food

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv ($Bq \cdot kg^{-1}$)*
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

A1.05 Soil

The LLDs in Table A.05 apply to the time of sample collection. Samples of approximately 200 g are counted for 5000 s.

Table A.05 Annual Dose at the LLD for Soil

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv ($Bq \cdot kg^{-1}$)*
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01 μSv	2.0E+01	5.0E+00 μSv

*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

A1.06 Seawater

The LLDs in Table A.06 apply to the time of sample collection for a 3.6 L sample counted for 5000 s for gamma; and a 6 mL sampled counted for 100 min for tritium. The dose is small due to the simple facts that the frigid waters of the Bay of Fundy discourage immersion and salt water is not consumable.

Table A.06 Annual Dose at the LLD for Seawater

Nuclide	*LLD* *($Bq \cdot L^{-1}$)*	*Dose at LLD* *(μSv)*	*Activity That Gives 5 μSv* *($Bq \cdot L^{-1}$)*
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

A1.07 Clams

Typical LLDs are given in Table A.07 for the edible portions of clams, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.07 Annual Dose at the LLD for Clams

Nuclide	*LLD (Bq·kg^{-1})*	*Dose at LLD (µSv)*	*Activity That Gives 5 µSv (Bq·kg^{-1})*
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

A1.08 Fish

Typical LLDs are given in Table A.08 for the edible portions of fish, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s.

Table A.08 Annual Dose at the LLD for Fish

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (µSv)*	*Activity That Gives 5 µSv ($Bq \cdot kg^{-1}$)*
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

A1.09 Lobster

Typical LLDs are given in Table A.09 for the edible portions of lobster, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s.

Table A.09 Annual Dose at the LLD for Lobster

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv ($Bq \cdot kg^{-1}$)*
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

A1.10 Dulse

Typical LLDs are given in Table A.11 for dulse, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.11 Annual Dose at the LLD for Dulse

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv ($Bq \cdot kg^{-1}$)*
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

A1.11 Sediment

The LLDs in Table A.12 apply to the time of sample collection. Samples weighing approximately 200 g are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.12 Annual Dose at the LLD for Sediment

Nuclide	*LLD ($Bq\cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv ($Bq\cdot kg^{-1}$)*
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 $\mu Sv\cdot h^{-1}$	3.0E+00	1.7E-02

* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

Appendix B: Sample Collection and Analytical Techniques

B1 Analytical Techniques

All environmental samples are analysed at the Health Physics Fredericton Laboratory. The following pages provide a general summary of the analytical techniques used in the laboratory. Sample collection, preparation and analysis are briefly described, but can be found in detail in the laboratory procedures.

The major analytical techniques and the instruments used in routine environmental analyses are summarised in the Table B.01.

Table B.01 Summary of Analytical Techniques

Analytical Technique	Instrumentation
Gamma Spectroscopy	Canberra 24% efficient* intrinsic, Ge detector in an Applied Physical Technology 10 cm graded lead cave; Canberra S-100 MCA
Liquid Scintillation (tritium and C-14)	Beckman LS 6000TA Liquid Scintillation Counter
Gross Alpha/Beta (Wet Chemical Analysis for Sr-89 and Sr-90)	Tennelec LB-5100 Alpha/Beta Counting System
Gamma Surveys	Eberline Model FH 40G-10 low range gamma survey meter (range 10 $nSv{\cdot}h^{-1}$ to 1 $Sv{\cdot}h^{-1}$ for 30 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-710A Automatic TLD Reader and UD-814A1 ($CaSO_4$) dosimeters

*relative to a 3x3 inch sodium iodide detector

In gamma spectroscopy analysis, all significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those that are produced in PLGS, and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma emissions. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

The peak search and analysis program SAMPO is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

1) selected nuclides of key fission and activation products
2) all other identified radionuclides, including natural radionuclides
3) detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be overlooked.

The usefulness of gross alpha/beta analysis lies primarily in showing trends and determining whether more detailed analyses should be done. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analysis for Sr-89,90 on GEM and LEM samples follow a method developed by Eichrom Industries Inc.[16] using a strontium specific chromatography resin. This method is similar to test method 05811-95 issued by the American Society of Tests and Materials (ASTM).

Liquid samples, other than milk, are acidified upon receipt to keep radionuclides from plating out on the container walls. Perishable samples are refrigerated or frozen.

B2 Sample Collection and Analysis

B2.01 Airborne Particulates

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter, through which air is drawn at about 60 $L \cdot min^{-1}$ for a 28 day continuous sample. The volume of air sampled (approximately 2400 m^3) is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the laboratory for analysis. Sampling is, therefore, continuous throughout the year, the only interruption (other than power failure or pump breakdown) being the few minutes for a filter change.

Air particulate filters are analysed by gamma spectroscopy as soon as possible after collection to ensure the detection of any short lived gamma emitters that may be present, and to minimise any decay corrections. Samples are counted for 5000 s on the Ge detector.

Approximately three days after the end of the sample collection interval, each filter is counted on the Tennelec alpha beta counter for 100 minutes for the simultaneous determination of gross alpha and gross beta activities. Counting is delayed to allow for the decay of the short-lived radon progeny that would otherwise complicate the analysis.

If alpha/beta levels are detected at twice the normal level, further investigation is initiated by longer gamma counts or radiostrontium determinations.

If levels of Sr-89,90, indicating 1% of Weekly DEL, are detected in the chemical analysis of GEM filters, then the air monitoring station particulate filters are also to be analysed for these radionuclides.

B2.02 Airborne Radioiodines

Airborne radioiodines are collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are Nuclear Consulting Services NUSORB® (47 mm diameter and 48 mm length), containing 5% TEDA by weight. Approximately 2400 m^3 of air is sampled continuously over 28 days at a flow rate of about 60 $L \cdot min^{-1}$ The volume of air sampled is measured with an in-line integrating dry gas meter.

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50 000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodines are detected, then the cartridges are re-analysed individually. Other fission product radioiodines, with much shorter half-lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If a significant release of radioiodines were noted from the station in this interval, the samples would be changed and analysed earlier to minimise errors from decay corrections.

B2.03 Airborne Tritium

A fraction of the flow in the air monitoring sample station is diverted through a molecular sieve container (Linde type 13X sieve material), to extract water vapour from the sampled air. Sample volume is measured with an in-line integrating dry gas meter.

Sampling is continuous at each location throughout the year, but is interrupted for a few minutes every month to exchange sieve containers. Since the amount of water absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted with a Dwyer flow meter to avoid saturation of the sieve material and to ensure adequate sample collection.

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is counted for 100 minutes.

B2.04 Airborne Carbon-14

An aquarium pump bubbles air through 2N NaOH (1 L), into which carbon dioxide and its C-14 component is absorbed. Carbon dioxide is regenerated from sodium carbonate by acidification and analysed for the determination of C-14 activity. The carbon dioxide is passed through a silica gel trap to remove moisture and tritium and then absorbed into the chemical Carbo-sorb® E until saturation is reached. After the addition of the scintillation cocktail Permafluor® E$^+$, the sample is analysed for 100 minutes by liquid scintillation counting.

B2.05 Environmental Gamma Radiation (TLD)

The environmental TLD is composed of one element of natural lithium borate with no extra filtration, and three elements of calcium sulphate with lead filtration of about 700 $mg\cdot cm^{-2}$. The badge is sealed in plastic, placed in a screw cap plastic container and suspended about 1 m above the ground for a period of three months. This arrangement measures the ambient gamma dose, whether it is from activity in the air, from the ground or cosmic in origin.

Readout is by the Panasonic UD-710A Automatic Reader. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ±10% at the 95% confidence level.

B2.06 Soil

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1.6 kg) of the top 25 mm of a 20 cm by 20 cm area of soil is placed in a disposable polyethylene container.

The soil is air dried overnight. If excessive moisture is present, the sample is dried on a disposable aluminum tray (at 100 °C). Organic matter and stones are removed. Approximately 0.25 kg of dry soil is counted by gamma spectroscopy for 5000 s.

B2.07 Food

Garden produce and berries, which are either collected or purchased, require no special preparation. The edible portion is put in a calibrated container and weighed. The sample is counted by gamma spectroscopy for 5000 s.

B2.08 Milk

A 4L sample is purchased and placed in a clean polyethylene container.

For gamma spectroscopy, a 3.6 L portion is measured into a marinelli beaker. Approximately 100 mL is distilled, and a 6 mL aliquot of the distillate is analysed by liquid scintillation counting for 100 minutes. Count times are 50 000 s for gamma spectroscopy and 100 min for tritium analysis.

B2.09 Water

A 4L sample of well water, pond water, lake water or surface runoff is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. After gamma analysis, well water samples (125-500 mL, depending upon the historical content of dissolved solids) are evaporated to dryness on stainless steel planchets for gross alpha/beta analysis. For tritium analysis, a 6 mL aliquot is analysed by liquid scintillation counting. For gamma spectroscopy, the sample is counted for 5000 s. For tritium and gross alpha/beta analyses, samples are counted for 100 min. A level twice the normal level for alpha/beta will initiate further investigation by longer gamma counts and/or Sr-89,90 analyses.

Measurements of gross alpha and beta are made about two weeks after sample collection. This delay avoids analytical interference from radon progeny, which decay with a half-life of about 3.8 days. Natural radon and radon progeny occur in well waters everywhere and are known to reach high concentrations in many New Brunswick locations.

B2.10 Vegetation

The only vegetation types routinely collected and analysed are tree lichen (Spanish moss) and various ground mosses such as Cladonia and Lycopodium. They concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to humans.

About 25 g or more of each of the samples is collected and air-dried before analysis. No special preparation is required. The sample is placed in a calibrated container, weighed and counted by gamma spectroscopy for 5000 s.

B2.11 Precipitation

Various forms of precipitation are collected continuously throughout the year.

A portion is removed for tritium analysis and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

B2.12 Sediment and Beach Surveys

Beach sediment samples are collected near the low tide mark, with preference being given to the top 10 mm of the fine sediment characteristic of tidal mud flats. A disposable polyethylene container is used to collect about 1 kg of sample. In addition, direct gamma radiation dose rate measurements are made at each sediment site using an Eberline Model FH 40G-10 low range gamma survey meter. The meter is held for one minute at a point one metre above the intertidal surface. After the sediment sample has been collected, this is repeated.

The sample is transferred to a disposable aluminum tray for drying at 80 °C. Dried, caked samples are broken into their original free granular form with a porcelain mortar and pestle and sieved through a 0.5 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments). Approximately 0.25 kg of dried sediment is counted by gamma spectroscopy for 5000 s.

B2.13 Seafood

The inshore fishery throughout the Maritimes has declined since the OERMP was started in 1982. Some of it has been closed to any kind of harvesting. However, species of local seafood are collected when available from local fishermen. Sampling focuses on fish, lobsters, aquaculture salmon and clams. Some of the areas where clam harvesting is prohibited are sampled with the permission of the Department of Fisheries and Ocean. Other seafood species are more mobile and can sometimes be found throughout the area: crab, periwinkles, scallops, herring, mackerel, dogfish, cod, haddock, sea urchin, mussels, and flounder. The severe restrictions placed on the inshore fishery as well as the depletion of stocks make many of these samples unavailable for periods of time sometimes spanning years. However, whenever they are available an effort is made to collect as many samples as possible. Approximately 0.5 kg of fresh seafood is collected per sample.

Approximately 0.25 kg of each sample is prepared for gamma spectroscopy. Lobsters are cooked first, and the edible meat is removed for analysis. Clams, periwinkles, and crab are analysed whole, with a yield factor applied to account for the mass of the inedible shell. Usually the edible portion of fish is analysed, although sometimes the whole fish is analysed. Samples are counted for 5000 s.

B2.14 Aquatic Plants

Dulse (*Rhodymenia palmata*), an edible seaweed which is commercially harvested in the area, is collected monthly when available. Other species of seaweed concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to humans.

A portion of the seaweed or dulse is put in a calibrated container and weighed. This is counted by gamma spectroscopy for 5000 s.

B2.15 Seawater

A 4 L sample is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

If levels of Sr-89,90, indicating 1% of Monthly DEL, are detected in the chemical analysis of the LEM composite, then the the seawater is also to be analysed for these radionuclides.

B2.16 Miscellaneous Samples

This category encompasses all of those samples collected that do not fall within the other categories. It is a mechanism by which the lab can track and evaluate media for potential inclusion in the program. It gives the program flexibility and freedom and encourages the scientific curiosity of laboratory staff. A few of the media types started out this way. As many as 50 samples per year are analysed, including deer liver, mud puddles, snow, sea urchin and mussels.

B2.17 Bore Holes

A 4 L sample of water is pumped out of the bore hole into a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis, a 6 mL sample of water is counted for 100 min by liquid scintillation techniques. For gamma spectroscopy, the sample is counted for 5000 s.

B2.18 Parshall Flume

PLGS staff collect a 4 L sample of water from the Parshall flume systems.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis, a 6 mL sample of water is counted for 100 min by liquid scintillation techniques. For gamma spectroscopy, the sample is counted for 5000 s.

B2.19 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; and dosimeter placement at key locations.

Although some extra precautions are observed due to the potential biohazard of some of these samples, they are analysed according to established procedures previously described.

Appendix C: Location Codes

A 5m	PLGS Dry Fuel Storage Facility - 5 m NNE from perimeter fence
A 10m	PLGS Dry Fuel Storage Facility - 10 m NNE from perimeter fence
A 15m	PLGS Dry Fuel Storage Facility - 15 m NNE from perimeter fence
A 20m	PLGS Dry Fuel Storage Facility – 20 m NNE from perimeter fence
A 25m	PLGS Dry Fuel Storage Facility – 25 m NNE from perimeter fence
A 50m	PLGS Dry Fuel Storage Facility – 50 m NNE from perimeter fence
A 75m	PLGS Dry Fuel Storage Facility – 75 m NNE from perimeter fence
A 100m	PLGS Dry Fuel Storage Facility – 100 m NNE from perimeter fence
A 118m	PLGS Dry Fuel Storage Facility – 118 m NNE from perimeter fence
A01R	Bocabec – GPS Reading – L 45° 10.111N, Lo 67° 0.378 W
A02R	Bocabec – field across from A01R
A03R	Bocabec – inter-tidal zone
A04	Bayside – Fairmile Farm
A05R	Letete
A06	Digdeguash
A07	Beaver Harbour
A08	Back Bay
A09	Chamcook
A10R	Grand Manan
A12	St. Andrews

A11	Oak Bay / Waweig
AECL	Atomic Energy of Canada Ltd., Chalk River (QA)
B 5m	PLGS Dry Fuel Storage Facility – 5 m WNW from perimeter fence
B 10m	PLGS Dry Fuel Storage Facility – 10 m WNW from perimeter fence
B 15m	PLGS Dry Fuel Storage Facility – 15 m WNW from perimeter fence
B 20m	PLGS Dry Fuel Storage Facility – 20 m WNW from perimeter fence
B 25m	PLGS Dry Fuel Storage Facility – 25 m WNW from perimeter fence
B 50m	PLGS Dry Fuel Storage Facility – 50 m WNW from perimeter fence
B 75m	PLGS Dry Fuel Storage Facility – 75 m WNW from perimeter fence
B 100m	PLGS Dry Fuel Storage Facility – 100 m WNW from perimeter fence
B 150m	PLGS Dry Fuel Storage Facility – 150 m WNW from perimeter fence
B 200m	PLGS Dry Fuel Storage Facility – 200 m WNW from perimeter fence
B01	New River Beach - inter-tidal zone
B02	Pocologan
B03	New River Beach - park
B04	New River Harbour to Pocologan Harbour
B10	Pennfield
BAXR	Baxter's Dairy
BB	PLGS – Boiler Blow-down
BD	Belledune GS

C01	Lepreau Harbour – inter-tidal zone
C03	Lepreau
CCW	PLGS – Condenser Cooling Water Duct
CH	Chatham GS
COG	CANDU Owners Group
D01	Little Lepreau Basin - inter-tidal zone (remnants of clam shack)
D02	Little Lepreau
D03	Little Lepreau – GPS Reading – L 45° 08.030 N , Lo 66° 27.686 W
D04	Little Lepreau Basin – inter-tidal zone (remnants of boat wreck)
DH	Dalhousie GS
DOE	US Department of Energy (QA)
DUMP	PLGS – onsite landfill
DWC	PLGS – drinking water fountains
E01	Maces Bay –GPS Reading–L 45° 06.306 N, Lo 66° 28.651 W
E02	Maces Bay – Fundy Senior Citizens Centre
E03	Maces Bay – inter-tidal zone
E04	Maces Bay Cemetery
E05	Fundy Shores Elementary School – outside (Thompson/Trynor's Field)
E06	Fundy Shores Elementary School – inside
E07	Near intersection of route 790, Maces Bay Rd. and County Line Rd.
E11	28 Ridge Rd., Dipper Harbour

E12	22 Ridge Rd., Dipper Harbour
E13	16 Ridge Rd., Dipper Harbour
E14	10 Ridge Rd., Dipper Harbour
E15	4 Ridge Rd., Dipper Harbour
EDU	Edutech Enterprises
EPA	US Environmental Protection Agency (QA)
F01	Welch Cove–GPS Reading–L 45° 04.782N, Lo 66° 27.986 W
F02	Welch Cove – inter-tidal zone
F03	190 Welch Cove Rd., Maces Bay
F04	195 Welch Cove Rd., Maces Bay
F05	181 Ridge Rd., Maces Bay
F06	132 Ridge Rd., Maces Bay
F07	68 Ridge Rd., Maces Bay
G01	Indian Cove – inter-tidal zone
G02	Point Lepreau – lighthouse
G03	offshore – within 2 km of Point Lepreau lighthouse
G04	PLGS – inter-tidal zone 1 km south of CCW out-fall
GEM	PLGS – Gaseous Effluent Monitor
GL	Grand Lake GS
H01	Duck Cove – duck pond
H02	offshore – close to PLGS condenser cooling water out-fall

H03	Duck Cove - inter-tidal zone
H04	PLGS – across the road from old site of Information Centre building
H05	PLGS - start of nature trail near old site of Information Centre trailers
HS	Hanson Stream Reservoir
I00	PLGS SRWMF Phase 1– general site area
I01	PLGS SRWMF Phase 1
I02	PLGS SRWMF Phase 2
I03	PLGS SRWMF Phase 2 – general site area
I10A	PLGS SRWMF Phase 1 Bore Hole A (BHA)
I10B	PLGS SRWMF Phase 1 Bore Hole B (BHB)
I10C	PLGS SRWMF Phase 1 Bore Hole C (BHC)
I10D	PLGS SRWMF Phase 1 at I01 Barn (Shallow Bore Hole)
I10E	PLGS SRWMF Phase 1 at I01 Barn (Deep Bore Hole)
I10F	PLGS SRWMF Phase 1 Bore Hole southeast from C structure
I10G	FUTURE BORE HOLE
I10H	FUTURE BORE HOLE
I10I	FUTURE BORE HOLE
I11A	PLGS SRWMF Phase 1 - south fence (east side)
I11B	PLGS SRWMF Phase 1 - south fence (centre)
I11C	PLGS SRWMF Phase 1 - south fence (west side)
I11D	PLGS SRWMF Phase 1 - west fence (south side)

I11E	PLGS SRWMF Phase 1- west fence (centre)
I11F	PLGS SRWMF Phase 1 - west fence (north side)
I11G	PLGS SRWMF Phase 1 - north fence (west side)
I11H	PLGS SRWMF Phase 1 - north fence (centre)
I11I	PLGS SRWMF Phase 1 - north fence (east side)
I11J	PLGS SRWMF Phase 1 - east fence (north side)
I11K	PLGS SRWMF Phase 1 - east fence (centre)
I11L	PLGS SRWMF Phase 1 - east fence (south side)
I1A1	PLGS SRWMF Phase 1 – Cell 1A1
I1A2	PLGS SRWMF Phase 1 – Cell 1A2
I20A	PLGS SRWMF PHASE 2 – well #4 (shallow) BH4
I20B	PLGS SRWMF PHASE 2 – well #4 (deep) BH4
I20C	PLGS SRWMF PHASE 2 - well #7 (shallow) BH7
I20D	PLGS SRWMF PHASE 2 - well #7 (deep) BH7
I20E	PLGS SRWMF PHASE 2 – well #6 (shallow) BH6
I20F	PLGS SRWMF PHASE 2 - well #6 (deep) BH6
I20G	PLGS SRWMF PHASE 2 – well #5 (shallow) BH5
I20H	PLGS SRWMF PHASE 2 – well #5 (deep) BH5
I20I	PLGS SRWMF PHASE 2 – well #2 (shallow) BH2
I20J	PLGS SRWMF PHASE 2 - well #2 (deep) BH2
I20K	PLGS SRWMF PHASE 2 - well #3 (shallow) BH3

I20L	PLGS SRWMF PHASE 2 – well #3 (deep) BH3
I20M	PLGS SRWMF PHASE 2 – well #1 (shallow) BH1
I20N	PLGS SRWMF PHASE 2 – well #1 (deep) BH1
I20P	PLGS SRWMF PHASE 2 – north from bore hole 1
I20Q	PLGS SRWMF PHASE 2 – south from bore hole 2 (shallow)
I20S	PLGS SRWMF PHASE 2 – south from bore hole 2 (deep)
I20T	PLGS SRWMF PHASE 2 – north from bore hole 2
I20U	PLGS SRWMF PHASE 2 – well #8 shallow (BH8)
I20V	PLGS SRWMF PHASE 2 – well #8 deep (BH8)
I21A	PLGS SRWMF PHASE 2 – Periphery – south fence (east side)
I21B	PLGS SRWMF PHASE 2 - Periphery – south fence (centre)
I21C	PLGS SRWMF PHASE 2 - Periphery – south fence (west side)
I21D	PLGS SRWMF PHASE 2 - Periphery – west fence (south side)
I21E	PLGS SRWMF PHASE 2- Periphery - west fence (centre)
I21F	PLGS SRWMF PHASE 2 - Periphery - west fence (north side)
I21G	PLGS SRWMF PHASE 2 – Periphery – north fence (west side)
I21H	PLGS SRWMF PHASE 2 - Periphery – north fence (centre)
I21I	PLGS SRWMF PHASE 2 - Periphery – north fence (east side)
I21J	PLGS SRWMF PHASE 2 – Periphery – east fence (north side)
I21K	PLGS SRWMF PHASE 2 – Periphery – east fence (centre)
I21L	PLGS SRWMF PHASE 2 - Periphery – east fence (south side)

I70	PLGS – woods between plant & SRWMF
I71	PLGS - Near Plant Monitoring Well MW01-10, northeast from RB
I75	PLGS – north 73° east, 85 m from the stack (on pole)
I86	PLGS – 2nd pole from SRWMF driveway heading toward outer gate
I87	PLGS –3rd pole from SRWMF driveway heading toward outer gate
I88	PLGS – 4th pole from SRWMF driveway heading toward outer gate
I89	PLGS -5th pole from SRWMF driveway heading toward outer gate
I90	At distribution line on west side of Point Lepreau Rd.
I91	100 m north of distribution line on west side of Point Lepreau Rd.
I92	200 m north of distribution line on west side of Point Lepreau Rd.
I93	300 m north of distribution line on west side of Point Lepreau Rd.
I94	400 m north of distribution line on west side of Point Lepreau Rd.
I95	500 m north of distribution line on west side of Point Lepreau Rd.
I96	on the old Dupont warning sign at the end of the old "dynamite road"
I97	on the west side of the clearing at the end of the old "dynamite road"
I98	PLGS – north of SRWMF PHASE 2 (200 m north of transmission line)
I99	PLGS – north of SRWMF PHASE 2 – (100 m north of transmission line)
IAEA	International Atomic Energy Agency (QA)
J00	PLGS – south, 180 m from the stack (on fence)
J01	PLGS - Near Plant Monitoring Well MW01-1, near surge shaft
J02A	PLGS - Near Plant Monitoring Well MW01-2 (shallow), SSE from RB

J02B	PLGS - Near Plant Monitoring Well MW01-2 (deep), SSE from RB
J20	PLGS – south 19° east, 115 m from the stack (on fence)
J35	PLGS – south 34° east, 135 m from the stack (on sign)
J70	PLGS – south 69° east, 70 m from the stack (on pole)
K00	PLGS - Near Plant Monitoring Well MW01-3 south from RB
K01	PLGS – 95 m west of south gate leading to the lighthouse
K02	PLGS Cooling Water Pump-house – east fence near surge shaft
K03	PLGS - Near Plant Monitoring Well MW01-4 SSW from RB
K03C	PLGS sewage lagoon (chlorine contact tank)
K03E	PLGS inactive drainage (east lagoon)
K03W	PLGS inactive drainage (west lagoon)
K04	PLGS - Near Plant Monitoring Well MW01-5, WSW from RB
KDRP	KD Radpro
L01	PLGS – site of old cement plant
L02	PLGS – switchyard
L03	PLGS – outer security building (main gate)
L04	PLGS – construction stores
L05	PLGS - Near Plant Monitoring Well MW01-6, WNW from RB
L06	PLGS - Near Plant Monitoring Well MW01-7, paved staff parking lot
L07	PLGS - Near Plant Monitoring Well MW01-8, construction parking lot
L08	PLGS - Near Plant Monitoring Well MW01-9, N beyond fire training area

LAB	Fredericton – Health Physics Laboratory
LEM	PLGS – Liquid Effluent Monitor
M02	PLGS – Administration Building (2nd floor)
MISC	Miscellaneous locations
MQ	Mactaquac GS
N01	Dipper Harbour – GPS Reading – L 45° 05.399 N, Lo 66° 25.154 W
N02	Dipper Harbour – GPS Reading – L 45° 06.106 N, Lo 66° 24.949 W
N03	Dipper Harbour – GPS Reading – L 45° 05.551 N, Lo 66° 25.449 W
N04	Dipper Harbour – inter-tidal zone
N05	Dipper Harbour – beach behind restaurant
N06	Dipper Harbour – offshore
NTS	Nuclear Technology Services Inc. (QA)
P01	Chance Harbour – GPS Reading – L 45° 07.494 N, Lo 66° 21.456 W
P02	Little Dipper Harbour
P03	Liberty Hill – GPS Reading – L 45° 07.043 N, Lo 66° 21.498
P04	Round Meadow Farm
P05	Chance Harbour – 2 km offshore
PLGS	PLGS – general
Q01R	Lorneville
RPB	Radiation Protection Bureau, Health Canada (QA)
RPC	Research and Productivity Council

S00	Saint John and surrounding area
S10	Hammond River
SPL	Spruce Lake reservoir
TAYR	Taymouth
X03R	Fredericton - Chestnut Complex lab
X04R	Fredericton – reference seafood
X05R	Fredericton – reference milk test
X06R	West of Fredericton (Silverwood)
X10	Fredericton Junction – Atlantic Dairy Institute
X12	York Mills
Y#####	Hemlock Knoll Regional Sanitary Landfill

Appendix D: Abbreviations

CCW	Condenser Cooling Water
CL	Critical Level
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	Canadian Standards Association
DEL	Derived Emission Limit
FWHM	Full Width Half Maxima
GEM	Gaseous Effluent Monitor
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
LEM	Liquid Effluent Monitor
LLD	Lower Limit of Detection
LSC	Liquid Scintillation Counter
NBEMO	New Brunswick Emergency Measures Organization
NIST	National Institute of Standards and Technology
NRC	National Research Council
NTS	Nuclear Technology Services
OERMP	Operational Environmental Radiation Monitoring Program
PLGS	Point Lepreau Generating Station
PROD	Power Reactor Operation Division
QA	Quality Assurance
QC	Quality Control
REPD	Radiation and Environmental Protection Division
RPB	Radiation Protection Bureau
SEA	Significant Environmental Aspect
SRWMF	Solid Radioactive Waste Management Facility
TLD	Thermoluminescent Dosimeter
USDOE	United States Department of Energy

Appendix E: Environmental Reports of Previous Years

PRE-OPERATIONAL (1976 - 1981)

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. October 1, 1976 to June 30, 1979. NBEPC-HP-79-1. J.A. Flanigan and J.J. Paciga. Sept. 1979.

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Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1980 to December 31, 1980. NBEPC-HP-81-1. J.K. Sutherland and J.A. Flanigan. July 1981.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1981 to December 31, 1981. NBEPC-HP-82-1. J.K. Sutherland. February 1982.

OPERATIONAL (1982 - 2004)

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1982 (to 1997) to December 31, 1982 (to 1997). HP-07000-83 (to 98)-1. J.K. Sutherland. March 1983 (to 1998).

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1998 (to 2004) to December 31, 1998 (to 2004). HP-07000-1999 (to 2005)-1. J.C. McCulley. April 1999 (to 2005).

Appendix F: References

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12. Bryant, P., *Methods of Estimation of the Dispersion of Windborne Materials and Data to Assist in Their Application.* UKAEA Report AHSB(RP)R42, 1964.

13. *Environmental Radiation Monitoring Program Procedures, HP-03541-2-EN Rev. 2,* Point Lepreau Generating Station Procedure Document, 2004.

14. *External Beta/Gamma Dosimetry Program, HP-03541-2-TL Rev. 5,* Point Lepreau Generating Station Procedure Document, 2004.

15. NBS Special Publication 456, *Measurements for the Safe Use of Radiation*, US Department of Commerce, 1976.

16. *Analytical Procedures SRW01 Rev. 1.3*, Eichrom Industries Inc., 1999.

Appendix G: Distribution List

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